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TRANSACTIONS

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VOL. 76. 1928.

ON THE TYPES OF ORIENTAL CARABIDAE DESCRIBED BY V. DE MOTCHULSKY

By H. E. ANDREWES.

[Read November 16th, 1927.]

By permission of the Director, Prof. Koschewnikow, and with the assistance of Mr. Boris Kuzin, both of the Zoological Museum of the University in Moscow, and to both of whom I offer my sincere thanks, I have been enabled to see a great many of the typical specimens from Motchulsky's collection. Many of his descriptions are so defective that identification of the species has always been difficult, and in many cases impossible. It was my object to see examples of as many species as possible, taking the least known first. This object has in a large measure been accomplished, and the following notes record the results of the examination of examples of about seventy species. Time has been a matter of importance in view of the forthcoming publication of my "Catalogue of Oriental Carabidae," which has already been delayed for a long time, and I shall hope, if opportunity offers, to add some notes on additional species later on. In any case, the immense majority of doubtful ones, excluding those of which the types have disappeared, are dealt with here, so that nearly all the numerous rectifications in synonymy, etc., which it is possible to make, appear here and will be included in the Catalogue. The region I am dealing with embraces India, Ceylon, Burma, the whole of the Malay Archipelago and Peninsula, Siam, Indo-China, Southern China, and Japan, the boundary in China being necessarily a little indefinite.

A long and interesting account of Motchulsky himself, who wrote first under the name of T. Victor and later under that of Victor de Motchulsky, has recently been published by Dr. W. Horn in the *Entomologische Mitteilungen*, and my notes are concerned only with his collections and in particular with the new species of CARABIDAE from the East of which he published descriptions. It is understood that the types from his collection all went to Moscow, cotypes

going to the Museum of the Academy at Petrograd. In addition to the species dealt with here, there are, as I learn from a list which I sent to Mr. Kuzin and which he annotated and returned, examples at Moscow of a further forty-four species, while of thirty-five others no specimens can at present be traced; the names of all of these are included in the Index, the former with one, the latter with two asterisks. Mr. Kuzin has been good enough to send me not only the type specimens, but all the specimens of each species to be found in the collection, which, as some examples are defective, has been of great assistance; generally speaking, the collection is, considering its age, in a reasonable state of preservation.

Motchulsky frequently used very thick pins, and, for mounting small specimens, a rather shiny cardboard, which is now often blackened on the upper surface. For the labels on Indian and Malay insects he used yellow, and for Japanese ones orange paper; the labels are in his own handwriting, and the name-label generally also bears the indication " Ind. or." In addition he sometimes used minute scraps of paper, coloured as above, to indicate localities; these sometimes have one or more letters on them, often undecipherable and of no great assistance now. In a few cases there is also a small written " type " label on white paper.

All the descriptions with which I am concerned in this paper appeared either in the *Moscow Bulletin*, or in the *Études Entomologiques*; in the former case there are six papers, and in the latter six yearly parts. The species have been numbered and the *Moscow Bulletin* papers have been taken first in chronological order, then the relevant years of the *Études Entomologiques* in the same way. The generic names given are those to which the species are now assigned; where these differ from those employed by Motchulsky, the latter are added in a parenthesis. In cases of synonymy an asterisk has been put against the name which is to stand; these indications are often new, but, where that is not the case, the fact is always mentioned. Numerous additional quotations might have been added, but only those have been inserted which seemed in the circumstances to be necessary. A few species have been redescribed, but only when no adequate description already existed.

Other collections in the Moscow Museum include those of Eschscholtz and Solsky; I have seen types of two species of each author, and refer to them at the end of the paper.

(i) *Bull. Mosc.* 1851, iv, pp. 506–10.

The fifteen brief descriptions of new species appearing in this paper refer chiefly to the genus *Tachys*, and, except in the one or two instances specified, the identifications made in my recent " Revision of the Oriental Species of the genus *Tachys* " (Ann. Mus. Civ. Gen. 1925, pp. 327–502) prove to be correct. There is one species only, referred to below, of which no example was sent. The labels on the specimens indicate that many of them came from Burma, and in one or two cases from Helfer; I feel little doubt that all of them came from Burma (probably Tenasserim) and that they were sent to Motchulsky either by the Prague Museum, or possibly by Dr. J. W. Helfer himself prior to his early death in 1840.

1. **Perigona (Nestra) ruficollis** (p. 506). Putz., Ann. Mus. Civ. Gen. 1873, 222; *id.* Ann. Mus. Civ. Gen. 1875, 728.

The labelled example is pinned, and in addition to the name bears the words " Ind. or. Birma "; there are three other examples and a fragment, all mounted

on card and without label. Putzeys' identification, on a Bornean example (which was formerly in the Genoa Museum, but cannot now be traced), seems correct. Bates misidentified various examples with Motchulsky's species (Ann. Mag. Nat. Hist. (5), xvii, 1886, 149, and Ann. Mus. Civ. Gen. 1892, 378), as pointed out by Fauvel (Rev. d'Ent. 1907, 104), who gave Bates' species the name of *P. annamita*. The species occurs in Burma, Siam, and the Malay region: there are specimens in the Prague Museum (Helfer coll.), the British Museum, the Brussels Museum, and my own collection.

2. **Perigona (Nestra) nigricollis** (p. 506). Putz., Ann. Mus. Civ. Gen. 1873, 222; *id.* Ann. Mus. Civ. Gen. 1875, 728.

Four examples, including one without head, mounted on card, and bearing a label "Ind. or. Birma," in addition to the name. A fifth mounted example is unlabelled and paler in colour than the others. Putzeys' identification of some Bornean specimens appears to be correct. The species is of the same size as *ruficollis* and bears a strong likeness to it, but the prothorax is brown and the basal fourth of the elytra reddish; further, whereas both in *nigrifrons* and *ruficollis* both intervals 1 and 2 are red, in *nigricollis* the red colour is confined to interval 1. The elytra are a little shorter and wider than in *ruficollis*, and the sides of the prothorax slightly, though evidently, sinuate before the hind angles, which are consequently somewhat sharper.

The species is found in Burma, Borneo, and Java. The examples seen by Putzeys, at that time in the Genoa Museum, cannot now be found, but there are specimens in the Prague Museum (Helfer coll.) and in my collection.

3. **Tachys (Trechus) fasciatus** * (p. 506) = *Tachys triangularis*; Nietn., Ann. Mag. Nat. Hist. (3), ii, 1858, 422; Andr., Rev. 350.

There are three examples labelled "Ind. or."

This synonymy is most unexpected; it has the advantage of disposing of an imaginary and elusive *Trechus*. Motchulsky's name has not, so far as I am aware, been used elsewhere in the genus *Tachys*, so that the name of *fasciatus* —a much more suitable one—will replace that of *triangularis*, and the *triangularis*-group of my Revision will become the *fasciatus*-group.

4. **Lymnastis (Lymnaeum) indicus** (p. 507). Andr., Revision Gen. Tachys, 494.

Ten examples with the name-label and the indication "Ind. or." only; they agree with the examples already seen, including Helfer's long series in the Prague Museum.

5. **Tachys sericeus** (p. 507). Andr., Rev. 362.

Four examples on three cards with two name-labels and the indication "Ind. or.," agreeing fairly with a specimen previously compared with the typical example in the Deutsch. Ent. Mus. I have seen other examples from Pusa (Pusa Coll.), Calcutta (Brussels Museum), Burma (Berlin Zool. Mus., ex coll. Helfer), Kuala Lumpur (F.M.S. Museums), and New Guinea (Brit. Museum, ex coll. Wallace).

6. **Tachys umbrosus** (p. 507). Andr., Rev. 488.

Five examples in all. Two examples on one card bear the label "*Tachymenis umbrosa*, Motch. Ind. or." and a further "type" label. One of the three other specimens is labelled "Birma." The species is a common one and widely distributed in European Museums.

7. **Tachys parallelus** (p. 507). Andr., Rev. 488.

Motchulsky had already in the previous year ("Die Käfer Russlands") described under this name a species from Georgia. The type of this, which is identical with *T. bistriatus*, Dufts. v. *rufulus*, Rey., was sent to me instead of that of the Eastern species, which I have not seen. I did, however, a year or two ago see a cotype of the latter in the collection of the Deutsch. Ent. Mus., and have no reason to doubt that this species is synonymous with *T. umbrosus* referred to in the previous paragraph.

8. **Tachys impressus** (p. 508). Andr., Rev. 353.

Five examples on one card, labelled "*Tachys impressa*, Motch. Ind. or.," and bearing also a "type" label. They agree with the typical examples in the Brit. Mus. and the Deutsch. Ent. Mus., as also with the Helfer specimens in the Prague Museum.

9. **Tachys dorsalis** (p. 508).

When my Revision was published I had seen no example, so far as I was aware, of this species, and had been quite unable to identify it. In these circumstances I could do no more than reproduce (p. 497) the original description. In the course of this work, however, after redescribing *Tachys obsolescens*, Bates (p. 361), I referred to two examples in the Prague Museum (Helfer coll.) in which the sutural stria only was impressed, striae 2 and 3 being just visible, and the elytra suffused with a larger cloud.

The five specimens of Motchulsky's species agree very well with these examples, though all of them are a little darker, and the extent to which striae 2 and 3 are visible is variable. After seeing these additional specimens, I think the species should be regarded as distinct and placed alongside *obsolescens*. One of the five examples is not labelled, but the other four are on one card and on the label is "Ind. or." These are the only examples I have seen.

10. **Tachys suturalis** (p. 508). Putz., Ann. Mus. Civ. Gen. 1875, 746; Andr., Rev. 433.

A single specimen on card labelled "*Tachys suturalis*, Motch. Ind. or.," and eight examples on another card labelled "*Tachyura suturalis*, Motsch. I. or. Birma"; these agree with the other examples referred to in the Revision. Helfer took a large number of specimens in Burma, which have since been distributed throughout the Museums of Europe; I have seen none with labels indicating any other origin.

11. **Tachys latissimus** (p. 508). Andr., Rev. 478.

There are five examples from Burma. The species was described as a *Tachys*, but referred later on by the author to his genus *Elaphropus*. In the Revision I put this species into synonymy with *T. haliploides*, Bates (Ann. Mus. Civ. Gen. 1892, 289), though with a mark of interrogation, but actually the typical examples do not quite agree with that species, or with the closely allied *T. gracilis*. Apart from its rather larger size, *haliploides*, as compared with *gracilis*, has wider elytra, more rounded at sides, and a smaller prothorax, the antennae pale and the apical spot on the elytra generally faint or wanting. *T. latissimus* proves to be a little smaller than the average *haliploides*, the elytra of the same shape, the prothorax relatively smaller; the antennae have almost entirely disappeared, but the two which remain are fuscous, as in *gracilis*,

and the apical spot is generally conspicuous, as in that species. The typical specimens of *latissimus* prove in fact to be intermediate between *haliploides* and *gracilis*. There are numerous examples of both species in the Prague Museum, whence no doubt Motchulsky's material came, and one is led to the supposition that all the specimens may really belong to one very variable species. The differences, however, seem at present too great to justify their union; *haliploides*, with its pale antennae and nearly uniformly pale elytra, seems the most distinct of the three and I treat it as standing by itself, but *gracilis* may reasonably be regarded as not more than a variety of *latissimus*.

12. **Tachys fumigatus** (p. 509). Andr., Rev. 466.

Five examples on one card labelled " *Tachyura fumigata*, Motch. Ind. or.," and agreeing with the typical specimen in the Deutsch. Ent. Mus.

13. **Tachys politus** (p. 509). Andr., Rev. 448.

There are eight examples on one card labelled " *Tachyura polita*, Motch. Ind. or. Birma," and one other example similarly labelled, but without the word " Birma "; they agree with the typical specimens already seen.

14. **Tachys sulcatus** (p. 509). Andr., Rev. 408.

One example labelled " *Tachyura sulcata*," Motch. Ind. or.," and six other examples on another card, similarly labelled but with the addition of " Birma," all agreeing with the typical specimens in the British Museum and at Berlin.

Motchulsky's name being preoccupied, I proposed for it in my Revision of the Eastern species of the genus the new name of *T. aratus*, though I mentioned the probability that *T. latus*, Peyron, from Asia Minor was synonymous with it. Quite recently I purchased some CARABIDAE which came from the collection of Dr. Melichar, and among them was a cotype of *T. jurečeki*, Reitt., also from Asia Minor, which proves to be identical with Motchulsky's species. This further confirmation of the occurrence of the species in Asia Minor, coupled with Bates' remarks and identification, seems now to justify the adoption of Peyron's name, and the synonymy will be as follows :—

Tachys latus, Peyron, Ann. Soc. Ent. Fr. 1858, 364, t. 9, f. 3.
,, *sulcatus*, Motch. (not Putz.), Bull. Mosc. 1851, iv, 509.
,, *jurečeki*, Reitt., Ent. Blätt. 1908, 50.
,, *aratus*, Andr., Rev. 408 (nom. nov.).

15. **Tachys (Lopha) ovatus** (p. 509). Andr., Rev. 463.

Seven examples on one card are labelled " *Tachylopha* (*Lopha*) *ovata*, Motch. Ind. or.," with an additional " type " label; there is also another specimen on a separate card. Yet another example, evidently from the Bowring collection, for it bears the well-known round label, with the No. 763 and date 7.12.51, is labelled (but not in Motchulsky's writing) " *Tachys albicornis*, Schaum, Hongkong." It also bears a doubled-up label " *Bemb. callipygum*, Chaud.," I think in Chaudoir's handwriting, a circumstance which I am not in a position to explain; Chaudoir's name is evidently a MS. one, but a species of *Bembidion* bearing this name was described by Boheman in the " Eugenie's Resa " (p. 17) from Hongkong.

The specimens agree with those already seen; the single one is very dark, but both this and the Hongkong example bear the normal number of pores on the elytra.

(ii) *Bull. Mosc.* 1861, i, pp. 98–108.

This work is entitled " Essai d'un Catalogue des insectes de l'île Ceylan " and contains a list of Coleoptera known to Motchulsky as inhabiting Ceylon. The new species of CARABIDAE described, which were nearly all taken by Nietner but retained in the author's collection, numbered thirteen, and specimens of eight of them have been sent to me for examination; none of these had been satisfactorily identified, and I give some account of them below. The remaining five species have all been identified with reasonable certainty, chiefly by Chaudoir and Bates, and their absence from my list is not therefore of any great moment.

16. **Tachys cinctipennis** (p. 99) = *T. tropicus*, Nietn.,* Ann. Mag. Nat. Hist. (3), ii, 1858, 421; Andr., Rev. 366. The solitary type is labelled " Ceyl. Colombo "; it is rather a dark specimen and the striae are less impressed than in the case of other examples I have seen.

Of this species, as of *dorsalis*, I had, when the Revision was written, seen no example, and I was therefore unable to do more than reproduce (p. 498) the original description.

17. **Perigona (Tachynotus) castanea** (p. 100, t. 9, f. 1).

This genus and species have never been identified, a circumstance which, as the author called his insect a " Tréchiaire," is hardly surprising, nor does the figure give much help in determining its affinities. There is a solitary example, apparently ♀, the label on which, in addition to the name, bears the words " Ind. or. Ceyl. Colom.," a second small label being marked " type." Though the generic characters are not all verifiable, the peculiar form of the submarginal stria on the elytra, bent inwards behind and bounded in front by a carina, indicates the genus *Perigona*; at the same time the very small prothorax and convex elytra give the specimen a very unusual appearance for this genus. A redescription is given below :—

Perigona castanea, Motch.

Length: 4·0 mm. Width: 1·7 mm.

Castaneous, the elytra somewhat sericeous: maxillary palpi, antennae, suture and margins of elytra, and underside testaceous.

Head (1·0 × 0·7 mm., with mandibles) convex, smooth, frontal furrows short, but fairly deep, curving outwards behind and reaching mid-eye level, bounded outwardly by a carina, clypeal suture fairly deep, mandibles and maxillae both long and slender, hooked at extremity, maxillary palpi long, last joint very sharply pointed and a little longer than penultimate joint, labial palpi wanting, mentum with a conspicuous tooth, eyes flat, evidently enclosed by the genae behind, which curve round rather sharply to neck, front supra-orbital pore very large, hind one placed well behind eye, antennae (5 basal joints only) pubescent from joint 4 (but as in other species of the genus joints 1 to 3 are semi-pubescent). *Prothorax* (0·8 × 0·9 mm.) convex, quadrate, smooth, equally contracted at extremities and widest at middle, base strongly arcuate (convex behind), apex truncate, sides bisetose, narrowly bordered, gently and evenly rounded, slightly sinuate in front of the obtuse hind angles; median line and front transverse impression moderately deep, hind transverse impression deep, running back obliquely from middle on each side to hind angle. *Elytra* (2·2 × 1·7 mm.) convex, ovate, smooth, widest a little behind middle, shoulders distinct, sides very narrowly bordered; striae 1 to 3 very lightly impressed, formed mainly by fine punctures, not reaching either base or apex, 4 to 8 obsolete, but just visible here

and there, 9 deep, very deep near apex, but not reaching suture; intervals flat, 3 with two minute pores at a half and three-fourths, but no pore visible in front. Microsculpture of prothorax and elytra consisting of fine transverse lines, which form a reticulation of very wide meshes; meshes on head isodiametric, but obsolete on disk.

As I know of no described species nearly resembling this one, I refrain from attempting any comparison.

18. **Clivina (Eupalamus ?) fulvaster** (p. 101).

One example labelled " I. or. Ceyl. Colomb."

19. **Clivina (Eupalamus ?) brunnescens** (p. 101).

Three examples, one labelled " I. or. Ceyl. Colombo," a second " Ind. or.," the third without label. According to the description specimens were also taken at Nuwara Eliya.

20. **Clivina (Eupalamus ?) rufipes** (p. 102).

Three examples, one labelled " I. or. Ceyl. Colom.," the other two unlabelled. Taken also at Nuwara Eliya.

21. **Clivina (Eupalamus ?) cordicollis** (p. 102).

Two examples, one labelled " I. or. Ceyl. Colomb.," the other " Tranqb." (no doubt Tranquebar).

The first example in the case of each species also bears a small " type " label. These four " *Eupalamus* " may conveniently be taken together, because they all belong to the same species, viz. *Clivina tranquebarica*, Bon.* (Obs. Ent. ii, 1813, 484), which will now have no less than twelve synonyms.

C. fulvaster is a very pale, probably immature specimen, with the surface of the prothorax irregularly striate. *C. rufipes* agrees in size and colour with *C. mordax*, Putz., while *C. brunnescens* differs only in having a dark reddish hue. *C. cordicollis* is a little larger and agrees exactly with the type of *C. foveicollis*, Putz., with which I have compared it.

22. **Metabletus (Apristomorphus) sexpunctatus** (p. 105, t. 9, f. 2) = *M. quadripunctatus*, Schm. Goeb.,* Faun. Col. Birm. 1846, 39; Andr., Trans. Ent. Soc. Lond. 1923, 17.

The genus is identical with *Metabletus*. There are five specimens, two on one card labelled with the name and " I. or. Ceyl. Mt. Nura," a third also labelled with the name and " Ceylan," the other two unlabelled. According to the description they came from Nuwara Eliya.

The presence of a third pore on the third elytral interval seems to be a fiction.

23. **Pentagonica marginata** (p. 105, t. 9, f. 3) = *P. erichsoni*, Schm. Goeb.,* Faun. Col. Birm. 1846, 48; Andr., Trans. Ent. Soc. Lond. 1923, 25.

A single example labelled " I. or. Ceyl. Mt. Patan." (= Mt. Patannas of the description). To the localities given in my former paper I can now add Singapore, Sarawak, Great Sangir, Batchian, and Hongkong.

(iii) *Bull. Mosc.* 1864, iii, pp. 180–240.

This and the two succeeding papers, which are a continuation of it, form the fourth article in the author's " Enumération des nouvelles espèces de

coléoptères rapportés de ses voyages." The article contains references to an immense number of species, and there are many descriptions of new ones. In the first part of the article eleven new species are described from the Indian region and South East Asia; of these I have seen examples of seven, on which I comment below, and, of the remaining four, three appear to be already satisfactorily identified.

24. **Abacetus (Pogonus) hindustanus** (p. 192) = *A. placidulus*, Walk.,* Ann. Mag. Nat. Hist. (3), ii, 1858, 203; Andr., Trans. Ent. Soc. Lond. 1919, 188.

One example is labelled with the specific name and the indication "Ind. or." A second unlabelled specimen is unusually large, of the size of *A. submetallicus*, Nietn., but presents all the other characters of *placidulus*. In the description the specimens are said to come from Tranquebar.

25. **Stenolophus japanus** (p. 203) = *S. propinquus*, Moraw.,* Bull. Acad. Petr. v, 1863, 261; Bates, Trans. Ent. Soc. Lond. 1873, 269.

One specimen from Japan. The above synonymy was indicated by Bates in 1873, though it is unlikely that he saw the type of either species. I have not seen Morawitz's type, but Motchulsky's specimen agrees with the examples taken by Mr. George Lewis in Japan and determined by Bates as *S. propinquus*.

26. **Stenolophus (Egadroma) apicalis** (p. 205) = *S. smaragdulus*, F.,* Suppl. Ent. Syst. 1798, 60.

A single example from Tranquebar, not differing from the typical form of the common Fabrician species, to which references in entomological literature are already very numerous.

27. **Stenolophus (Egadroma) nitens** (p. 205) = *S. smaragdulus*, F.,* Suppl. Ent. Syst. 1798, 60; Andr., Trans. Ent. Soc. Lond. 1919, 178.

The description gives the locality as Bombay, and the type example is so labelled, but there are three other examples labelled Burma.

This is the small form of the species, to which Bates (Ann. Mus. Civ. Gen. 1889, 103) gave the name *S. cyanellus*; it is unspotted or with a shoulder spot, while the apex of the elytra is often widely ferruginous, with the two apical spots sometimes showing.

28. **Stenolophus (Egadroma) splendidus** * (p. 205) = *S. harpaloides*, Bates, Ann. Mus. Civ. Gen. 1892, 347.

There are six examples, three on one card with the name and the indication "Ind. or." Two of the remaining three specimens are unlabelled, but the other has on it two labels "Ind. or." and "21." According to the description the specimens came from Burma, and, as the Helfer collection in the Prague Museum contains a large number, I imagine that Motchulsky's specimens came from this source.

29. **Odacantha (Casnonia) haemorrhoidalis** (p. 219) = *O. punctata*, Nietn.,* Ann. Mag. Nat. Hist. (3), ii, 1858, 178; Andr., Ann. Mag. Nat. Hist. (9), xix, 1927, 106.

The type is apparently lost, for the name-label, which also bears the indication "Ind. or.," is attached to a pin with a blank piece of card on it, together with a locality-label "Tranquebar." There is, however, a second specimen,

agreeing with the traditional identification, but having nothing attached to the pin but a small square piece of yellow paper.

In my paper referred to above I mentioned not only these two species, but also *O. fuscipennis*, Chaud., and *O. flavicauda*, Bates, both of which evidently differ from *haemorrhoidalis*. I have in my collection a cotype of Bates' species, and a specimen compared, though not agreeing, with the type of *fuscipennis*. From notes made at the time I now feel no doubt that these two species are identical, and the synonymy will therefore be :—

O. fuscipennis, Chaud.,* Bull. Mosc. 1850, i, 26 = *O. flavicauda*, Bates, Trans. Ent. Soc. Lond. 1873, 303.

30. **Lebia infuscata** (227 Table) = *L. circumdata*, Schm. Goeb.,* Faun. Col. Birm. 1846, 44; Andr., Trans. Ent. Soc. Lond. 1923, 21.

Two examples in poor condition, with "Ind. or." on the name-label, one of them with a minute locality-label, which is undecipherable. Motchulsky himself put the species alongside Schmidt-Goebel's, differentiating it only by the most slender characters.

(iv) *Bull. Mosc.* 1864, iv, pp. 297–355.

In the second part of the article, which is comprised in this paper, there are descriptions of twenty-eight new Eastern species, and I have been able to examine specimens of twenty of them. Six others have been recognised by various authors, but the remaining two, both species of *Abacetus*, have never been satisfactorily identified.

31. **Catascopus subquadratus** (p. 302).

A single example labelled "Ind. or.," in rather a broken condition and with the abdomen missing. It does not quite agree with any other species known to me and I therefore redescribe it.

Catascopus subquadratus, Motch.

Length : 8·0 mm.

Head green, prothorax green-blue, elytra dull blue, though vaguely greenish at sides and behind; joint 1 of antennae, tibiae, and tarsi dark red; femora ferruginous.

Head (2·05 mm. wide) convex, frontal furrows moderately deep, parallel, bounded outwardly by a rounded carina, a second sharper carina between this and eye, vertex with some short, rather faint, longitudinal striae, a very faint neck constriction, eyes very large and prominent, left antenna with 1, right with 5 joints only remaining, surface somewhat uneven, with some minute scattered punctures. *Prothorax* (1·4 × 1·95 mm.) convex, base truncate, with its sides a little oblique, apex slightly emarginate, front angles moderately sharp, sides with an obtuse angle just before middle, nearly straight both before and behind, but gently sinuate at a fifth from base, hind angles right and not very sharp, slightly reflexed; median line deep, deeper near base, transverse impressions and basal foveae also fairly deep, surface finely transversely striate. *Elytra* (4·7 × 3·4 mm.) rather flat, a little depressed behind base, shoulders square, sides nearly straight, though faintly sinuate before middle, apex obliquely truncate, the truncature very slightly emarginate on each side, outer angle obtuse though little rounded, inner one acute without being very sharp; striae moderately deep, clearly punctate in front and at sides, intervals only slightly convex, 4 somewhat wider on disk than the adjoining ones (stria 3 being deflected a little inwards), 5 raised for a short distance near base, 7 narrow and inwardly subcarinate, 3 with three pores on the interval, at a fifth, a half, and four-fifths, surface

smooth and somewhat glossy. Microsculpture formed by a reticulation of moderately transverse meshes, very distinct on elytra, faint on head and prothorax. Underside smooth, sterna glabrous, metepisterna elongate.

Closely allied to *C. cyaneus*, Chaud., and *C. lissonotus*, Andr., but differing a little from both of them. Smaller than the former, but similarly coloured, with a little more green here and there and paler femora. Head proportionately larger and less striate at sides; prothorax relatively wider, the surface a little more evidently striate; elytra flatter, less noticeably compressed at sides and depressed behind base, the outer angle of apical truncature much less evident (though not rounded, as in *elegans*), striae shallower, especially near apex, interval 5 raised near base, interval 7 less carinate, the two hind pores on 3 placed rather nearer apex.

32. **Catascopus aeneus** (p. 303) = *C. fuscoaeneus*, Chaud.,* Rev. & Mag. Zool. 1872, 247.

A solitary example labelled "Pulo Pinang." Chaudoir had presumably not seen Motchulsky's type, but his identification was correct. Motchulsky's name was preoccupied and Chaudoir's was proposed to replace it.

33. **Catascopus excisus** (p. 303).

Another solitary example, the label on which reads "*Catascopus excisus*, Motch. Ind. or." This indication of origin appears again on a second small label, while a third reads "*elegans* ?," a species to which the specimen bears little resemblance. It is, in fact, only a rather large (16·0 mm. long) colour variety of *C. facialis*, Wied. (Zool. Mag. i, 3, 1819, 165), dull green in colour, with a little blue showing on the clypeus and neck, as also on intervals 5 to 7 and marginal channel of elytra. The hind angles of the prothorax project a little laterally as in var. *angulatus*, Chaud.* (Berl. Ent. Zeitschr. 1861, 117), with which variety I associate it.

34. **Colpodes (Loxocrepis) nigriceps** (p. 310).

A single example, labelled "Ind. or.," which is in poor condition and has been damaged—apparently by *Anthrenus*. The specimen is a little deformed, the right side of the prothorax being rather longer than the left. I cannot identify it with any other species and therefore, as far as its condition permits, redescribe it below.

Colpodes nigriceps, Motch.

Length: 9·5 mm. Width: 3·3 mm.

Piceous, the elytra blue-black; head and joints 1 to 4 of antennae (all that remain) black; prothorax, femora, and tarsi ferruginous; tibiae (including knees) dark brown.

Head convex, shiny, with a moderate neck constriction, frontal foveae fairly deep, eyes not prominent, joint 4 of antennae quite as long as 3. *Prothorax* convex, subcordate, a third wider than head and as much wider than long, widest a little before middle, base truncate, with somewhat oblique sides, front angles rounded, sides (presumably) bisetose, moderately explanate, reflexed, rounded in front and faintly sinuate before base, hind angles reflexed, obtuse but not rounded; median line and front transverse impression slight, base distinctly impressed, the foveae rounded and fairly deep, surface smooth and shiny on disk, a little uneven along margins. *Elytra* moderately convex, fully a half wider than prothorax, rather less than twice as long as wide, shoulders square, sides nearly parallel, though very slightly dilated behind, margin faintly sinuate before apex, which

is narrowly and indistinctly truncate, without mucro; striae moderately impressed, very finely crenulate, hardly deeper behind; intervals nearly flat, 3 with three pores, at a fifth, just behind middle, and five-sixths respectively, surface moderately smooth and shiny, with a distinct elongate depression on each side on basal half. Microsculpture of elytra consisting in extremely fine and closely placed transverse lines, which on the prothorax become inconspicuous; the head has an indistinct reticulation of isodiametric meshes. Meso- and metatibiae only slightly sulcate. Meso- and meta-, but not protarsi evidently bisulcate; joint 4 strongly bilobed in protarsi, moderately in meso- and metatarsi; joint 5 not ciliate beneath.

Very nearly allied to *C. chloropterus*, Chaud., but in that species the legs and joint 1 of the antennae are ferruginous, joints 1 to 4 of the antennae distinctly shorter, the eyes prominent, and the microsculpture of the elytra less fine, the transverse lines forming distinct, though very wide meshes.

35. **Calathus (Pristosia) piceus** (p. 312). Putz., Ann. Soc. Ent. Belg. 1873, 91; Bates, Trans. Ent. Soc. Lond. 1883, 253 = *Calathus pectiniger*, Putz.,* Ann. Soc. Ent. Belg., 1873, 86.

Putzeys failed to identify Motchulsky's species, but Bates seems to have been acquainted with it. Motchulsky's name is the older one, but it is preoccupied and therefore Putzeys' name must stand. The elytra, a fragment of the abdomen, and one hind leg of a single specimen are all that remain here. The locality label is "Ind. or."

The two specimens on which Putzeys drew up the description of his species are at Rennes, where I saw them some years ago, when I made a few notes. One of these examples bears a label "*Pristosia picea*, Motch.," but I am not aware by whom this was written. The convexity of the elytra, together with the absence of any setiferous pore on interval 3 are important points in this genus. With only fragments of Motchulsky's type remaining, certainty is perhaps impossible, but I feel practically no doubt regarding the identification. The genus seems hardly separable from *Calathus*.

36. **Lorostema alutacea** * (p. 330) = *Feanus spinipennis*, Bates, var. *nigripes*, Andr.

Two examples, both with "Ind. or." on the name-label and both with a locality-label marked "Tranq." (= Tranquebar); one of the specimens has no head. This is another species on which, so far as I am aware, no comment has ever been made, though Chaudoir has a note on the genus (*Bull. Mosc.* 1871, iii, 283), which was unknown to him, and also to Bates, who redescribed it under the name of *Feanus*.

The synonymy will now be as under :—

Lorostema alutacea, Motch., Bull. Mosc. 1864, iv, 330.
,, *nigripes* (*Feanus*), Andr., Ann. Mag. Nat. Hist. (9), xvii, 1926, 257.
var. *spinipennis* (*Feanus*), Bates, Ann. Mus. Civ. Gen. 1889, 107.

37. **Microcosmus (Epicosmus) transversus** (p. 332) = *M. flavopilosus*, Laf.,* Ann. Soc. Ent. Fr. 1851, 222.

Three examples, labelled respectively Nepal, Tranquebar, and "Ind. or." The species, which appears to have been unnoticed hitherto by other authors, was described as coming from Nepal; it is fairly common in India, and spreads through South East Asia as far as Japan.

38. **Chlaenius (Callistoides) malachinus** (p. 335). Chaud., Mon. des Chléniens, Ann. Mus. Civ. Gen. viii, 1876, 280.

A solitary example, in fairly good preservation, labelled "Ind. or." Chaudoir identified his specimens quite correctly with Motchulsky's species, but in his Monograph put this into synonymy with *C. pudicus*, F., quite another species.

39. **Chlaenius viridanus** (p. 339). Chaud., Mon. 223.

A single ♂ specimen, which is much rubbed and at some time or other has been attacked by *Anthrenus*; the locality, according to the label, is "Ind. or."

Chaudoir did not known this species, but he put it into his Monograph with a translation of the author's description. I have seen no Eastern insect at all similar to this, and believe Motchulsky's type to be an example of *C. aestivus*, Say (Trans. Am. Phil. Soc. ii, 1825, 62), from North America. I am consequently removing the name from my Catalogue of Oriental species.

40. **Chlaenius nigricoxis** (p. 339) = *C. flavofemoratus*, Cast.,* Étud. Ent. 1834, 81; Andr., Trans. Ent. Soc. Lond. 1919, 207.

This confirms the synonymy already published. The solitary specimen came from Hongkong and is labelled "China." The species occurs also in Burma, Indo-China, and the Malay Archipelago. In his Monograph (p. 94) Chaudoir identified the species correctly, but introduced it under Motchulsky's name; on the previous page he misidentified Castelnau's species, which he put erroneously into synonymy with *C. femoratus*, Dej. (Spec. Gen. ii, 1826, 328).

41. **Chlaenius binotulatus** (p. 341) = *C. posticus*, F.,* Suppl. Ent. Syst. 1798, 57; Andr., Trans. Ent. Soc. Lond. 1921, 159.

Another single, well-preserved ♀ specimen labelled "Tranqueb." Chaudoir (Mon. 54) was very doubtful about this identification, but I was able to confirm it at Copenhagen. The species has been described six times, each time under a different name, by five authors.

42. **Chlaenius maculipennis** (p. 341) = *C. lafertei*, Guér.,* Voy. Deless. ii, 1843, 36.

Two specimens in a fragmentary state, though easily recognisable, both labelled "Ind. or." Chaudoir's identification (Mon. 86) was accurate. The species was also named and described by two other authors.

43. **Chlaenius (Epomis) fuscomarginatus** (p. 345).

Only one specimen, labelled "Ind. or." Chaudoir in his Monograph, refers the species to the African *C. subsulcatus*, Dej. (Spec. Gen. v, 1831, p. 642), without further comment. The example is a ♀ and only three joints of the antennae remain. I know of nothing quite like it from the East, and believe it to be an example of *C. laetus*, F. (Ent. Syst. iv, 1794, 443), from South Africa; I am therefore eliminating the name from my Catalogue of Eastern species.

44. **Chlaenius (Chlaenites) nicanus** (p. 346). Bates, Trans. Ent. Soc. Lond. 1873, 249; Chaud., Mon. 88 = *C. circumdatus*, Brullé, var. *xanthopleurus*, Chaud.,* Bull. Mosc. 1856, iii, 230; *id.* Mon. 115.

A single specimen from Hongkong in a good state of preservation. The species has hitherto been treated as a variety of *C. spoliatus*, Rossi (Faun.

Etrusc. Mant. 1792, 79). Motchulsky himself rather prepared the way for this misidentification, which was actually made by Bates, whom Chaudoir in his Monograph seems to have followed without hesitation. The Japanese variety of *spoliatus*, now known as var. *nicanus* will require a new name, and I suggest for it var. *motchulskyi*, nom. nov.

45. **Chlaenius (Poeciloistus) laevicollis** (p. 348) = *C. quadricolor*, Oliv.,* Enc. Méth. v, 1790, 344; F., Syst. Eleuth. i, 1801, 180; Chaud., Mon. 154.

The unique example is labelled " Ind. or." Chaudoir's identification was accompanied by a mark of interrogation, but, after examining the type, I agree with him. The prothorax is unusually narrow in front, though not more so than in some examples in my collection.

In the previous paragraph Motchulsky had alluded to *C. quadricolor*, F., and his example, labelled " Tranq." (= Tranquebar), was correctly identified. Chaudoir supposed (Mon. 157) that it belonged to his closely related *bengalensis*.

46. **Chlaenius (Poeciloistus) glabricollis** (p. 348).

A single specimen, with both the name and locality-labels marked " Ind. or." Chaudoir suspected (Mon. 162) that the species might prove to be identical with his *phaenoderus*, but the resemblance is superficial only, and actually it belongs to a later group with emarginate labrum. The appearance of the specimen suggested to me an African rather than an Asiatic origin, and, on examining the material in the British Museum, I found six examples from Sherbro' Island, Sierra Leone, which, though darker and differing in some further slight particulars, appear to belong to the same species. I am therefore ruling the name out of my Oriental list. Motchulsky's name is preoccupied and his description is confined to four short lines; a more detailed one will be found below.

Chlaenius victor, nom. nov.

Chlaenius glabricollis, Motch.

Length: 14·0 mm.

Metallic green above, black beneath and somewhat iridescent; palpi, joint 1 of antennae, and legs ferruginous (but apex of palpi, rest of antennae, and tarsi are darker).

Head (2·65 mm. wide) convex, minutely, indistinctly, and not very closely punctate, frontal foveae small and shallow, a very slight neck constriction, eyes rather flat, genae evident, labrum distinctly though not very deeply emarginate, palpi slender, slightly dilated and squarely truncate at apex, antennae long and slender, joint 3 about a fourth longer than 4. *Prothorax* (3·3 × 4·2 mm.) convex, quadrate, base emarginate at middle, a little oblique at sides, apex slightly emarginate, sides with a narrow reflexed border, gently rounded in front, straight behind, explanate close to hind angles, base a little wider than apex, hind angles obtuse, a little rounded, and somewhat reflexed; median line fine, not reaching extremities, transverse impressions very slight, basal foveae linear, fairly long, and very deep, converging slightly forwards, surface nearly smooth, a little uneven, some minute, vague, scattered punctures, chiefly across base and round margins. *Elytra* (8·5 × 5·5 mm.) moderately convex, oval, basal border sinuate on each side, forming an angle at shoulder, a slight sinuation near apex; striae deep, quite clearly though minutely punctate, 4 turning inwards at base, 6 and 7 not reaching base; intervals convex, less so near apex, 3, 5, and 7 seriately punctate, the punctures on 3 adjoining striae 2 and 3 rather irregularly, those on 5 and 7 usually adjoining striae 5 and 6 respectively, surface minutely, irregularly, and sparsely punctate. Microsculpture of elytra formed by isodiametric meshes, which become granular towards apex, so that the surface is shiny in front and

dull behind; prothorax and head with microsculpture hardly visible. Prosternum, metasternum, metepisterna, and sides of ventral surface more or less punctate; prosternal process bordered, metepisterna without sulcus, only a little longer than wide; profemora ♂ edentate, protarsi ♂ with three strongly dilated joints, metatarsi long and slender.

In Chaudoir's table the species would come alongside *lissoderus*, Chaud.

47. **Chlaenius (Poeciloistus) dilatatus** (p. 348). Chaud., Mon. 157.

One example, a well-preserved ♀, labelled "Ind. or." Chaudoir's identification was correct. The species is found in India, Burma, Siam, and Cambodia.

48. **Lesticus (Trigonomima) politocollis** * (p. 349) = *Lesticus semiviolaceus*, Chaud., Ann. Soc. Ent. Belg. xi, 1868, 152.

The genus *Trigonomima* proves to be identical with *Lesticus*, which was evidently unknown to Motchulsky. There is a single example ♂. On the name-label is "Ind. or.," but there is also a small locality-label apparently reading "Hyma." (= Himalayas?), and in the description the locality is given as "Nord des Indes orientales." I have a ♀ example in my collection, which has been compared with Chaudoir's type, and there is another ♀ example in the British Museum. Motchulsky's specimen is narrower, the elytral intervals are raised, and the surface is shinier, as we should expect in the ♂; the colour of the head and prothorax is blue-green, the elytra nearly black. These slight differences appear to be either sexual or individual, and I do not feel any doubt about the identification.

49. **Chlaeminus biguttatus** (p. 351). Chaud., Bull. Mosc. 1869, ii, 401.

Fragments of two specimens, bearing the locality name "Tranq." (= Tranquebar), and quite adequate for the recognition of the species. Chaudoir's identification, in his Monograph of the genus *Abacetus*, was correct. The species is fairly common in India and Ceylon, and extends through Siam and Cambodia as far as Java.

(v) *Bull. Mosc.* 1865, iv, pp. 227–313.

In this paper, containing the third part of the article, four Indian species were described on pp. 227–9, and I have not seen examples of any of them. All belong to the genus *Abacetus*, or at all events allusions to them are contained in Chaudoir's Monograph of that genus. Two of the four species have been fairly satisfactorily identified, but the other two are quite unknown.

(vi) *Bull. Mosc.* 1866, ii, pp. 393–446.

This is a continuation of the Catalogue of the insects of Ceylon published in the Bulletin of 1861. Only one new species is described.

50. **Abacetus (Caricus) testaceipes** * (p. 394) = *A. anomalus*, Chaud., Bull. Mosc. 1869, ii, 367.

A solitary example, labelled "Ceylon." Both genus, which is superfluous, and species are omitted in Gemminger and Harold's Catalogue. The species, which is confined to Ceylon, should be known as *Abacetus testaceipes*, Motch.

(vii) *Études Entomologiques*, ii, 1853.

Of the two Chinese species described in this part I have seen the type of one.

51. **Chlaenius posticalis** (p. 44). Chaud., Mon. 273.

A solitary specimen labelled "China bor.," of which only the hind body remains. The only other described species with which confusion seems possible is *C. naeviger*, Moraw. (Bull. Acad. Petr. 1863, v, 324), the elytra of which are very similar to those of *posticalis*, but, after comparing a number of specimens of both species with the type, I am satisfied that Chaudoir's identification is accurate.

(viii) *Études Entomologiques*, iii, 1854.

Only one species was described, said to come from "Shingai" (presumably Shanghai).

52. **Chlaenius biguttatus** (63) = *subhamatus*, Chaud., Bull. Mosc. 1856, iii, 211; *id.* Mon. 274 = *micans*, F.,* Ent. Syst. i (1), 1792, 151; Chaud., Mon. 62; Andr., Trans. Ent. Soc. Lond. 1924, 463.

A single example labelled "Schangai." Chaudoir identified Motchulsky's species with his own, but did not know that of Fabricius.

(ix) *Études Entomologiques*, vii, 1858.

The three years 1855–7 produced a few descriptions of Oriental species, but I have not seen any of the types, nor I think are any of them in doubt. In 1858 there appeared descriptions of three species, two from India, and one from Ceylon; I have seen the typical specimens of all three.

53. **Apotomus atripennis** * (p. 22).

54. **Apotomus fuscus** (p. 22). Bates, Ann. Soc. Ent. Fr. 1889, 264; Dupuis, Ann. Soc. Ent. Belg. 1911, 36 = *A. xanthotelus*, Bates, Ent. Month. Mag. xi, 1874, 95; *id.* Ann. Mus. Civ. Gen. 1889, 100; *id.* Ann. Mus. Civ. Gen. 1892, 286; Bouch., Ann. Soc. Ent. Fr. 1903, 170; Dupuis, Gen. Ins. 1911, t. f. 11 = *A. sumbawanus*, Heller (not Dupuis), Deutsch. Ent. Zeitschr. 1916, 275; Andr., Ann. Mag. Nat. Hist. (9), xvii, 1926, 254.

I take these two species together. Of *atripennis* there is a solitary example, with "Ceyl. Colombo" on the name-label, and two other small labels, one marked "type," the other a little yellow one marked "C." Of *fuscus* there are five examples (one fragmentary); the indication "Ind. or." appears on the name-label, and there is also a small round yellow label, with nothing legible on it, but we know from the description that the specimens came from India. The example of *atripennis* is slightly larger than those of *fuscus*, and the prothorax is relatively a little larger, but I can see no substantial difference between the specimens, and regard them as belonging to one species, which should be called *A. atripennis*, as that name stands first on the page.

55. **Oodes nepalensis** (p. 171) = *O. chalceus*, Chaud., Bull. Mosc. 1857, iii, 30; *id.*, Mon. des Oodides, Ann. Soc. Ent. Fr. 1882, 357; = *O. subolivaceus*, Laf.,* Ann. Soc. Ent. Fr. 1851, 271 (note 4).

The single type is labelled "Nepal" and agrees very well with the other two types.

(x) *Études Entomologiques*, viii, 1859.

In this year some fifteen species were described, including several which it has hitherto proved quite impossible to identify. I have seen examples of

ten of these; of the remaining five only one appears to offer any serious difficulty, and, as the description of this is an unusually long and detailed one, it may yet be possible to recognise it.

56. **Pentagonica transparipes** (p. 29) = *P. pallipes*, Nietn.,* Journ. As. Soc. Beng. 1856, vi, 525.

There are three mounts, on two of which there remain only slight relics of an insect; one of these bears a label with the name and "Ind. or. Ceylon," the second has no label. The third mount has two specimens on it in a fair state of preservation, the label bearing the name and the words "Mt. Nura El. Ceyl." Bates' identification (Ann. Mag. Nat. Hist. (5), xvii, 1886, 209) was accurate.

The species occurs in Ceylon, the Malay Peninsula, Sumatra, Sumbawa, and the Philippine Is.

57. **Parena bicolor** (32). Chaud., Bull. Mosc. 1877, ii, 207.

One example from Java. In 1872 Chaudoir described his genus *Crossoglossa* (Ann. Soc. Ent. Belg. xv, 1872, 177), which had already been described a year earlier by W. Macleay for an Australian insect, under the name of *Phlocodromius* (Trans. Ent. Soc. N.S. Wales, ii, 1871, 85). The genus *Parena*, to which Chaudoir referred with some contumely, proves to be identical, and this name must replace the later ones; it has at least the advantage of being much shorter. This synonymy has already been briefly indicated (see Andrewes, Ins. Samoa, iv, Col. 1, 1927, 13). I have seen no second example of the species, and therefore redescribe it below.

Parena bicolor, Motch.

Length: 8·5 mm.

Testaceous; head and prothorax red, elytra metallic green, vaguely cupreous at base and apex, joints 4 to 11 of antennae and metasternum piceous.

Head (1·8 mm. wide) rather flat, smooth, slightly striate near eyes, front with a V-shaped impression in the middle, the foveae moderately deep, neck slightly constricted, eyes very large and prominent. *Prothorax* (1·4 × 2·0 mm.) convex, cordate, extremities truncate, front angles very strongly rounded, sides explanate, with a narrow reflexed border, (presumably) bisetose, gently sinuate before base, hind angles rounded; median line fine, but deeper at extremities, transverse impression and basal foveae fairly deep, surface smooth, the front and hind margins slightly and vaguely uneven. *Elytra* (5·0 × 3·5 mm.) moderately convex, with square shoulders, dilated behind and widest behind middle, apex truncate but with outer angles completely rounded, a depression on each side of disk and another at margin, both at about basal third; striae rather lightly impressed, finely, closely, and very clearly punctate, intervals moderately convex, 1 and 7 narrower than the rest, 3 with three pores, one close to base and two at two-fifths, both adjoining stria 3, three at five-sixths, adjoining stria 2, surface smooth, with a faint isodiametric microsculpture. Underside smooth.

The species will easily be recognised by its colours. Smaller than *nigrolineata*, Chaud., and rather smoother, the head and prothorax relatively smaller, the elytra more dilated behind, the intervals a little more raised.

There is a South Indian and Burmese species strikingly like *bicolor*, but differing in one or two particulars. As it appears to be of some economic importance, I describe it below:—

Parena rubripicta, sp. nov.

Of the same size as *bicolor* and similarly coloured, except that the disk of prothorax is more or less suffused with a piceous tinge, and the elytra, which vary from metallic-green to blue-green, have a common elongate red spot, extending outwards to stria 2 or sometimes 3 at middle, tapering at ends and not reaching either base or apex (larger in the Momeit example, and reaching stria 4). The head and elytra hardly differ, but the prothorax is smaller and narrower, barely wider than head, the sides less sinuate before base and the angles less rounded, the basal transverse sulcus not so deep.

MADRAS: Nilgiri Hills, Kallar, 1000 feet, 2 ex. taken beating in November (*H. L. Andrewes*); Nilambur (*S. N. Chatterjee*—Forest. Res. Inst.) 4 ex., 7.ix.–9.x. 1925, predaceous on *Hybloea puera* larvae. BURMA: Bhamo (*Y. R. Rao*—Pusa Res. Inst.) 1 ex.; Momeit (*Doherty*—Brit. Mus.) 1 ex.

The type is in my collection.

58. **Dicranoncus (Menera) quadridens** * (p. 32) = *D. amabilis*, Chaud., Ann. Soc. Ent. Fr. 1859, 350 (note) and 359.

This imperfectly characterised genus proves to be identical with *Dicranoncus*. One example, which has not, I think, hitherto been referred to by any other writer. Both in the description and on the name-label the specimen is said to come from Java, but there is also a minute yellow locality-label reading "Sum." (= Sumatra?), so that we are left in some doubt. The species is known independently from both islands.

The two names were published in the same year, but the preliminary note in Vol. viii of the *Études Entomologiques* is dated 26 Dec. 1858, and the contents of the volume all refer to that year. Probably therefore it appeared in the first half of 1859, whereas Chaudoir's Monograph of the genus *Colpodes* did not appear until August of that year. Hence the priority is given to Motchulsky, and the species should be known as *Dicranoncus quadridens*.

59. **Colpodes (Euplynes) bispinus** (p. 33).

In Gemminger and Harold's Catalogue the locality is given as Java, though there is nothing in the description to justify this. The label attached to the unique ♂ specimen bears the name and in addition "Ind. or. Ins.", while there is a further small round yellow label with the letters "Sum.," probably indicating Sumatra. The genus is *Colpodes* and I have compared Motchulsky's type with many other specimens from the East without finding anything quite like it. Accordingly I give a redescription below, the more necessary as the author's description is confined to a few words.

Colpodes bispinus, Motch.

Length: 7·0 mm.

Testaceous: elytra blue-green, green at margins and apex, joints 4 to 11 of antennae and knees fuscous.

Head (1·30 × 1·25 mm.) convex, smooth, with rather short, shallow, frontal foveae, barely reaching mid-eye level, clypeal suture very fine, neck slightly constricted, eyes moderately prominent, antennae rather thick, joint 3 a little longer than 4. *Prothorax* (1·2 × 1·55 mm.) moderately convex, quadrate, base truncate, its sides slightly oblique, rather wider than apex, which is a little emarginate, sides very finely bordered, reflexed, gently rounded and narrowly explanate in front, rather more widely explanate and very feebly sinuate behind, marginal setae wanting, but there are apparently pores just before middle in the marginal channel and on the hind angles, which are a little obtuse, reflexed, but not much rounded; median line moderately deep, transverse impressions very clearly

marked, hind one with a double row of dark, more or less underlying pores, which hardly break the surface, but extend forwards a little way along sides, surface otherwise smooth. *Elytra* (4·5 × 3·0 mm.) convex, shoulders very distinct, sides nearly parallel, strongly emarginate near, and with a short spine at apex; striae moderately deep throughout, impunctate, 5 to 7 a little deeper near base, and 4 and 5 at a third from apex, where the surrounding surface is lightly depressed, scutellary striole rather short; intervals only slightly convex, 8 with a short impression just before middle, 3 with three pores at a third, a half, and three-fourths, marginal series subinterrupted at middle, surface smooth. A microsculpture of fine lines forming strongly transverse meshes is visible on the elytra, almost invisible on head and prothorax. Underside smooth, metepisterna elongate and conspicuously bordered; tarsi outwardly sulcate, joint 4 deeply emarginate in the protarsi, slightly so in the other two pairs of legs, in the metatarsi the outer lobe longer than the inner one, joint 5 apparently glabrous beneath.

Most nearly allied to *C. rufitarsis*, Chaud. (Bull. Mosc. 1850, ii, 385), though coloured more like *C. andrewesi*, Heller (Ent. Mitt. 1926, 92). A little smaller than the former, the head and prothorax differing little, except that the hind angles of the latter are less sharp; elytra with the slight depression on their surface placed rather further back, the emargination behind deeper, the striation a little deeper and more regular, stria 2 not deflected outwards at apex, 8 not nearly as deep, 7 no deeper than the other striae. It is possible that the species may be identical with *C. smaragdipennis*, Chaud. (Ann. Soc. Ent. Fr. 1859, 351), of which I have no example for comparison.

It may be mentioned that there are a *C. bispinosus*, Chaud. (1878), and a *C. bispinis*, Bates (1882).

60. **Anchomenus (Agonothorax) ceylonicus** (p. 36). Bates, Ann. Mag. Nat. Hist. (5), xvii, 1886, 146.

Four examples altogether and unrecognisable fragments of two others on separate pins; three on one card are labelled "*Agonothorax ceylonicus*, Motch. Ceylon, Mt. Nu. E." These specimens were taken by Nietner at Nuwara Eliya, and they agree well with Mr. George Lewis' specimens, determined by Bates, and now in the British Museum.

61. **Perigona (Nestra) nigrifrons** (p. 38, t. 1, f. 1). Putz., Ann. Mus. Civ. Gen. 1873, 220; Bates, Ann. Mag. Nat. Hist. (5), xvii, 1886, 149.

Four examples, of which one only is labelled with the specific name and "Ceylon Mt. Nura El." (Nuwara Eliya), and we are told in the description that they were taken by Nietner. Putzeys seems to have identified the species correctly and gives a long description of it from an example in the Genoa Museum, which has since disappeared. Bates' identification was also accurate, and there is another Ceylonese specimen in the British Museum.

62. **Tachys flaviculus** (p. 39) = *T. ceylanicus*, Nietn.,* Ann. Mag. Nat. Hist. (3), ii, 1858, 423; Andr., Rev. 436.

Ten examples on one card labelled "*Tachyura flavicula*, Mots., Ceylan" and bearing also a "type" label; also a single specimen similarly labelled. Motchulsky received these specimens from Nietner, who appears to have taken them near Colombo; they agree with the typical examples already seen.

63. **Tachys impressipennis** (p. 39). Andr., Rev. 346.

Five examples, with fragments of four others, all on one card, labelled "*Tachyura impressipennis*, Motch., I. or. Ceyl. Col." and bearing also a "type" label; they agree with the other typical specimens seen.

64. **Tachys acaroides** (p. 39). Andr., Rev. 469.

There are ten examples on one card labelled "*Tachyura acaroides*, Motsch., I. or. Ceyl. Colomb.," and a single specimen on another card, similarly labelled with the name and the indication "Ind. or." All the specimens seem to have been sent by Nietner, and agree with those previously seen.

65. **Microlestes fuscipennis** (p. 122) = *M. exilis*, Schm. Goeb.,* Faun. Col. Birm. 1846, 42; Bates, Ann. Mus. Civ. Gen. 1892, 420; Andr., Trans. Ent. Soc. Lond. 1923, 19.

Two specimens on one card, with the name and locality "Ind. or." I suspect that, like Schmidt-Goebel's, Motchulsky's examples came from Helfer's Burmese Collection. Without a comparison of types there must be some uncertainty, but I feel little doubt about this identification.

(xi) *Études Entomologiques*, ix, 1860.

About a dozen species were described in a paper on the insects of Japan. I think all of them have been identified, but I have only seen the types of two of them.

66. **Chlaenius corpulentus** (p. 7) = *C. pallipes*, Gebl.,* Mem. Nat. Mosc. vi, 1823, 128; Chaud., Mon. 222.

Four examples from Japan, one of them labelled "type."

67. **Chlaenius arcuaticollis** (p. 7) = *C. inops*, Chaud.,* Bull. Mosc. 1856, iii, 239; *id.* Mon. 262.

A large ♂ example from Japan, labelled "type" and in a good state of preservation. Chaudoir's identifications of this and the preceding species were quite accurate.

(xii) *Études Entomologiques*, xi, 1862.

The volume for 1861 contained a continuation of the Japanese paper, and, as the Carabidae had already been dealt with in the previous year, no fresh descriptions appear. In the volume for 1862, the last of the series, there are descriptions of five Eastern species. Two of these, of which I have not seen the types, appear to have been successfully identified: of the other three I received the typical examples for examination and comment on them below.

68. **Lymnastis pullulus** * (p. 31) = *L. levatus*, Andr., Ann. Mus. Civ. Gen. 1925, 497

A single example labelled "Ind. or." The specimens which I described in the "Revision of the Oriental Species of the genus *Tachys*," cited above, came from Calcutta.

69. **Tachys (Polyderis) tenellus** (p. 35) = *T. truncatus*, Nietn.,* Ann. Mag. Nat. Hist. (3), ii, 1858, 421; Andr., Rev. 375.

Two examples on one card, labelled "*Polyderis tenella*, Motch., Ind. or.," but bearing also two other labels, viz. "Birma" and "type." The author says at the end of the description that the specimens came from the Indian continent, so that there is a discrepancy in the evidence. I cannot detect any rounded pores on the mentum, and in other respects also these examples agree with *truncatus*, a species widely distributed in South East Asia.

70. **Tachys (Elaphropus) gracilis** (p. 36). Andr., Rev. 477.

Five examples labelled "Ind. or.," and probably received from Helfer. This species was mentioned by name, but not described, in the volume for 1859 (p. 10). I have already discussed it under No. 11, *T. latissimus*, of which I consider it a variety.

J. F. Eschscholtz.

The collection of this author is in the Moscow Museum, and the unique types of two Eastern species, both described in the Zoological Atlas, part v, 1833, have been sent to me for examination.

1. **Chlaenius guttatus** (p. 26). Chaud., Mon. 49.

The type came from Manila, and was correctly identified by Chaudoir, who, however, treated it as a variety of *C. binotatus*, Dej. (Spec. Gen. ii, 1826, 302). An earlier name for the species is *C. flaviguttatus*, Macl. (Ann. Jav. 1825, 14; Andr., Trans. Ent. Soc. Lond. 1919, 141), *guttatus* being a variety of it.

2. **Oodes sulcatus** (p. 28). Chaud., Mon. des Oodes (i), Ann. Soc. Ent. Fr. 1882, 335.

The type, a ♂ specimen from Manila, is in moderate condition. Without any apparent justification, Gemminger and Harold included the species in the Munich Catalogue under the genus *Systolocranius*. Chaudoir commented on this in his Monograph, but knew nothing and expressed no opinion about it. To me it appears to be a true *Oodes*, and the only example I have seen. I redescribe it below, but it should be mentioned that the condition of the mouth and legs has prevented any thorough examination of those parts.

Oodes sulcatus, Eschsch.

Length: 9·0 mm. Width: 3·75 mm.

Black, shiny: palpi and joint 1 of antennae ferruginous, rest of antennae brown, legs piceous.

Head subconvex, neck moderately constricted, eyes fairly prominent, genae short but evident, labrum sexsetose, with the inner pores very small, clypeus trapezoidal, truncate in front, a pore adjacent to each of the oblique sides (setae abraded), clypeal suture obsolete, and just behind its site, on each side of front, a fairly large and very deep rounded pore, antennae slender, extending little beyond base of prothorax, palpi subtruncate, mentum with a short but not apparently bifid tooth, surface smooth. *Prothorax* moderately convex, half as wide again as head, and as much wider than long, widest a little in front of base and strongly contracted to apex, which is moderately emarginate and with bordered sides, sides gently rounded and narrowly bordered, the border disappearing just before base, hind angles about right, but a little rounded, with a distinct pore (seta abraded—if ever present); median line extremely fine, but a little deeper behind, basal impressions short, moderately deep, converging a little in front and somewhat removed from base, surface smooth, a vague, oblique depression on each side. *Elytra* rather flat, ovate, as wide at base as prothorax, but widest at about middle, a little more than a half longer than wide, sides very distinctly emarginate before apex, basal border straight, joining scutellary striole at base of stria 1; striae deep, deeper at sides, finely punctate on basal half, but only subcrenulate behind, 1 and 2 arising in an umbilicate pore, the other striae not quite reaching base, all very deep near apex, scutellary striole rather deep, fairly long, punctate; intervals rather flat on disk, but very convex at sides and behind, 3 without pores, 8 not narrower than the other intervals, its inner margin subcarinate near base,

9 very narrow, disappearing near base and apex, surface smooth. A microsculpture of isodiametric meshes on head and prothorax, elytra with fine transverse lines, which join irregularly to make very wide meshes. Underside somewhat uneven; prosternal process unbordered, the declivity carinate, sides of metasternum and metepisterna punctate, latter a little longer than wide; ventral segments bisetose, apical one with a large pore on each side, somewhat removed from margin; protarsi ♂ with three strongly dilated joints.

In the depth of the striae the species recalls *Oodes rhodopus*, Bates, and *Holcocoleus latus*, Laf., but in other respects it is not much like either of them. The deep rounded pores on the front distinguish it from the other species of the genus.

Philippine Is.: Manila.

S. M. Solsky.

The types of the new species described by Solsky in Fedchenko's "Reise in Turkestan" (Zool. Col. i, 1874) are at Moscow, and I have seen two of them, viz. those of *Nebria psammophila* (p. 12), and *N. limbigera* (p. 13), both of which agree with the traditional identification. These two Central Asian species are of interest to Indian entomologists because both of them have crossed the Himalayas; both are found in Kashmir, and *limbigera* has also been found in the North of Kumaon.

Note.—I recently sent to Mr. Axel Reichardt at the Museum of the Academy of Science, Petrograd, a list of the species of Carabidae occurring in South East Asia and described by Motchulsky, of which no examples were to be found at Moscow. He has been kind enough to examine the Petrograd collections to ascertain if specimens of any of these had found their way to the Museum there, and I learn from him that examples of the two following were all that could be discovered:—

Cymindis rivularis, Ins. Sib. 1844, 45, t. 2, f. 7.
Metabletus (*Dromius*) *lateralis*, Études Ent. 1855, 82.

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* Indicates a species in the Moscow University Museum, of which I have seen no example.
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Tachynotus castaneus, Motch., 6.
***Tachypus semilucidus*, Motch.
Tachys acaroides, Motch., 19.
,, *albicornis*, Schaum, 5.
,, *aratus*, Andr., 5.
,, *bistriatus*, Dufts., 4.
,, *ceylanicus*, Nietn., 18.
,, *cinctipennis*, Motch., 6.
,, *dorsalis*, Motch., 4, 6.
,, *fasciatus*, Motch., 3.
,, *flaviculus*, Motch., 18.
,, *fumigatus*, Motch., 5.
,, *gracilis*, Motch., 4, 20.
,, *haliploides*, Bates, 4.
,, *impressipennis*, Motch., 18.
,, *impressus*, Motch., 4.
,, *jurečeki*, Reitt., 5.
,, *latissimus*, Motch., 4, 20.
,, *latus*, Peyr., 5.
,, *obsolescens*, Bates, 4.
,, *ovatus*, Motch., 5.
,, *parallelus*, Motch. (1850), 4.
** ,, *parallelus*, Motch. (1851), 4.
,, *politus*, Motch., 5.
,, *rufulus*, Rey, 4.
,, *sericeus*, Motch., 3.
,, *sulcatus*, Motch., 5.
,, *suturalis*, Motch., 4.
,, *tenellus*, Motch., 19.
,, *triangularis*, Nietn., 3.
,, *tropicus*, Nietn., 6.
,, *truncatus*, Nietn., 19.
,, *umbrosus*, Motch., 3, 4.

Tachyura acaroides, Motch., 19.
,, *flavicula*, Motch., 18.
,, *fumigata*, Motch., 5.
,, *impressipennis*, Motch., 18.
,, *polita*, Motch., 5.
,, *sulcata*, Motch., 5.
,, *suturalis*, Motch., 4.
**Tanystola japonica*, Motch.

**Tetragonica fusca*, Motch.
**Tetragonoderus notaphioides*, Motch.
Trechus fasciatus, Motch., 3.
**Trichisia cyanescens*, Motch.
**Trichotichnus congruus*, Motch.
***Trigonognatha cuprascens*, Motch.
TRIGONOMIMA genus, 14.
Trigonomima politocollis, Motch., 14.

TWO COLLECTIONS OF BUTTERFLIES FROM THE S.E. CORNER OF THE SUDAN

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Plates I–III and Two Text-figures.

A journey along the northern frontier of Uganda in the Chua district gave me an opportunity in December 1925 of taking three weeks' local leave on one of the mountain ranges which lie along the Uganda–Sudan frontier in the Mongalla Province. I selected the Didinga country, since, so far as I knew, no naturalist had ever visited that remote area, and it was thought that the fauna might yield interesting links between Abyssinia and East Africa. This proved to be the case, and in addition a strong West African element was found, which helps us to understand the presence of West African forms in Abyssinia.

My wife accompanied and collected with me, being the first white woman to visit Didinga.

The position of the country is shown on the accompanying map (Text-fig. 1), from which it will be seen that the greater part of the mountain range lies between the parallels of 33°30′ E. and 33°45′ E., but that a strong spur projects to the S.E. as Mt. Latuke, reaching an elevation of 8935 feet, whereas the main mass of Didinga does not exceed 7000, the administrative headquarters, Nagichot station, being 6700 feet above sea-level. The parallel of 4°15′ N. runs through Nagichot.

The large-scale map (p. 27) shows the relations of Didinga to other neighbouring mountains, of which the Imatong range about 50 miles to the west should be particularly noticed, for it was there that Capt. A. L. Kent-Lemon made, in 1919, the collection which he presented to the Hope Department of the Oxford Museum. During my leave from Uganda in the latter half of 1926 I was able to compare this fine collection with mine from Didinga, which is also in the Hope Department, and have referred to it in this paper. There are, as will be seen, some surprising and interesting differences between the two collections.

These various mountain ranges, rising sharply from a very hot, dry plain at less than 3000 feet above sea-level, are well forested on their summits, and form a series of stepping-stones connecting the forests of the Congo and the western part of Mongalla Province with Abyssinia on the east, and with other mountains along the edges of the great Rift Valley which connect up with Mt. Elgon in Kenya Colony. The Hope Department also possesses, through the kindness of Lt.-Col. R. S. Wilson, a fine collection dated 1904–5 and 1917–19 from the Nuba Mountains, very much further north in the Sudan, on the west side of the Nile. Constant reference was also made to this collection for the purposes of ascertaining the range of species, but the locality is so far removed from the Imatong and Didinga mountains that it cannot be considered to be comparable with them. The Hope Department has also a very fine collection from S.W. Abyssinia sent by H.M. Consul, Mr. Arnold Hodson, C.M.G., in 1925. Constant reference was made to this collection and it will be seen that in some respects

the Didinga specimens have affinity with those from Abyssinia, as would be expected from the geographical relationships of the areas.

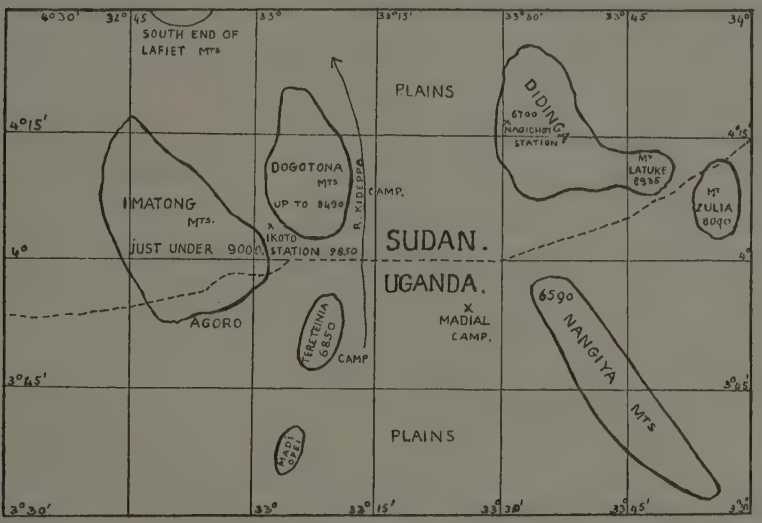
The small-scale map (Text-fig. 2) shows the relative positions of the areas from which the four collections now to be discussed have come.

Didinga was *terra incognita* until after the military expedition which, some years after the war, cleared out all the outlaws and raiders from the northern parts of Uganda and Kenya, and from the southern parts of Abyssinia, who made Didinga their refuge. Early in 1922 Mr. J. H. Driberg commenced the administration and "peaceful penetration" of the Didinga people, a small and

TEXT-FIG. 1.

isolated tribe, numbering, I believe, only about 1500 adult male tax-payers. Owing to Mr. Driberg's kindness my wife and I availed ourselves of his house at Nagichot and were enabled to live in great comfort in country which was practically unknown and certainly unsafe five or six years ago. The general character of the country is as follows. The whole area is a comparatively level plateau, deeply cut by valleys running into it from the hot, dry plain. The lower slopes of the mountains are covered with open bush which gradually changes as one ascends, and becomes heavy forest which grows along the headwaters of all the streams and fills up the valleys at their origin. This rich forest also covers large areas of the flat top of the range, but much of this is merely grass-land, the grass being, at the most, about four feet in height. (See Plate I.)

I noticed the same sudden edge to the forest belts that had seemed so characteristic of the Sesse Isles of L. Victoria, where the forest ends abruptly like a wall and suddenly changes into grass. As regards the larger animals, it may be said that Bush-buck are the largest mammals of Didinga, and frequent the dense bush which is still uncut, even in Nagichot station itself. Beautiful long-plumed black-and-white *Colobus* monkeys abound in the forests, where their deep growling noise is one of the first sounds of life to be heard in the early morning. A large *Cercopithecus*, dark grey, with the tail and top of the head black, was the only other monkey noticed in the forests. A species of baboon frequents the more rocky parts of the escarpment, and its skin is in much request among the natives for capes to hang over the shoulders. Among birds I particularly noticed a large dark-blue plantain-eater with crimson wings,



TEXT-FIG. 2.

which, to eye and ear, as it bounded about in the forest, was apparently the same as the species so common in the forests of L. Victoria.

The climate of Didinga is sufficiently indicated by the accompanying meteorological data (p. 51), systematically taken by Mr. Driberg, and by Major Wynne-Finch of the Scots Guards, who was in charge of the station during Mr. Driberg's absence.

It will be seen that we were collecting during the average second driest month of the year, January only having less rain than December. The average rainfall per year (since April 1922 when the records were commenced) is 41·86 inches; the rainfall for 1925 was 30·38. The maximum fall of rain recorded for 24 hours since the records were commenced is 1·98 inches. The maximum temperature ever recorded is 82·9 F., the minimum 49·6 F.

The main object of the present paper is to describe the butterflies of Didinga. When a species mentioned was also taken in the Imatong Mountains by Kent-Lemon or the Nuba Mountains by Wilson the fact is indicated thus: I +, or N +. Negative results are similarly indicated by — signs. The Hodson

Abyssinian collection is similarly referred to as A + or —. A species taken by Kent-Lemon but not by my wife and myself is cited in brackets. Thus it was hoped that a fairly complete list might be compiled from the Didinga and Imatong collections, showing the fauna of the mountains on that part of the Uganda–Sudan frontier. I was unfortunately unable, owing to lack of time, to identify the numerous LYCAENIDAE and HESPERIIDAE in the Kent-Lemon collection which we did not find on the Didinga Mountains. The paper is therefore incomplete in that respect. There also was not time to identify and compare all the Pierines, or the LYCAENIDAE and HESPERIIDAE from Abyssinia.

Very fortunately Canon St. Aubyn Rogers was at Oxford for a week and gave me the benefit of his unrivalled knowledge in identifying the specimens. To him, Dr. Karl Jordan and Mr. N. D. Riley I would express my grateful thanks. Dr. F. A. Dixey, F.R.S., very kindly identified the Picrines, and to him also thanks are due. Professor Poulton has, as always, been ready at any moment with kind help and advice in the preparation of this paper and has kindly consented to see the proofs after my return to Uganda.

It may be said, as a final preliminary, that the butterfly fauna of the hot, dry plains between the Imatong and Didinga mountains is very different from that on the mountains. It may be expressed, in a few words, as a *Teracolus* fauna, a term which will be readily understood by anyone who has collected in Africa. The Nuba Mountains collection is decidedly richer in *Teracolus* than either of the two now to be described.

The nomenclature and arrangement followed is that given by Aurivillius in Seitz's *Macrolep.*, xiii. This was adopted for convenience and uniformity.

PAPILIONINAE.

1. Papilio rex, subsp. nov. **franciscae.** (Pl. II, fig. 1 ♂; fig. 2 ♀.)

This interesting new geographical race is named after my wife, who took the first specimen in Didinga. I —, N —.

11 ♂ and 4 ♀ were captured either in the forest along streams where they drank from the mud, or on flowers at the edge of the forest. In appearance, as in distribution, it is intermediate between *rex rex*, Oberth., of East Africa, and *rex abyssinicus*, Poult., of Abyssinia. *P. rex abyssinicus* (*Proc. Ent. Soc.*, 7 Oct., 1925, pp. xliii–v) is described as being intermediate between *rex rex* and *rex schultzei*, Auriv., from the Cameroons, having the outer margin of the fore-wing only very slightly curved inwards but having, unlike the latter, " a very slight trace of bright orange-brown fringing the lower (inner marginal) border of the sickle-shaped mark in area 1*b* " (on the fore-wing).

The description of *rex franciscae* is as follows :—

Male.—The shape of the fore-wing is intermediate between *rex abyssinicus* and *r. rex*, as shewn by the degree of curvature of the outer margin. The upperside of the fore-wing bears, on the average, very much less of the orange-brown colour than in *rex rex*, although the amount is variable. It ranges from the slight trace described in *rex abyssinicus* to a degree in which the whole of the sickle-shaped mark in 1*b* is of that colour, and there may also be a slight suffusion with orange-brown at the base of the cell. The rest of the fore-wings and the hind-wings are black with creamy-white markings.

An interesting feature of *rex franciscae* is the great development of a " mealy " patch on the fore-wing of the male. Specimens of *rex* from Nairobi show a varying development of this patch, which lies in area 1*b* between the end of the sickle-shaped basal mark and the large spot distal to it. When most developed this patch extends into area 2 in

front of the spot just mentioned. It is seen under a lens to be clothed with long hairs. In *rex franciscae* these hairs are much longer and more conspicuous and the patch is on the average larger than in typical *rex*. This is not the case with the single specimen of *rex abyssinicus* in the Hope Collection, in which the patch is as in *rex rex*.

On the under surface there is only a minute trace of orange-brown suffusion at the base of the fore-wing, even less than in the Oxford specimens of *rex rex* in which there is least of this colour. The strong orange-brown costal markings on the base of the hind-wing are as in *rex rex* and *rex abyssinicus*.

Female.—The pattern is black and creamy-white, but has the orange-brown at the base of the fore-wing on the upperside more strongly marked than in the male. It is, however, always less developed than in the Oxford series of *rex rex*. One female has only very little more orange-brown than the male which shows the greatest development of this colour. In its maximal development the orange-brown never reaches distally as far as the proximal edge of the two nearest white spots. It is also interesting to note that this orange-brown colour in *rex franciscae* is rather of the darker tint of *rex mimeticus* than of *rex rex*. *P. r. franciscae* has probably been influenced by interbreeding with the former race to the south in Uganda, where it mimics *Tirumala mercedonia* with a darker shade of brown than *T. formosa*.

Type.—A male, taken 16.xii.1925 (Pl. II, fig. 1), in the Hope Collection. Paratypes have been given to the National Collection and to the collections at Tring and Witley.

In both males and females some of the specimens, as received at Oxford, show a curious irregular pale orange tint replacing the white of the large basal spots on the hind-wing, particularly on the underside. Prof. Poulton reported this by letter as soon as he saw the specimens and asked if this was the case when they were fresh, as it suggested a chemical change induced by the heat of the journey through the Sudan via Khartoum. I replied that while the butterflies had been seen fluttering at flowers the general impression was black and white, and, so far as my memory served me, the darkening of these spots had occurred in the post. It was unfortunate that I had left Didinga long before the query was received.

P. rex franciscae completes a series which shows the gradual assumption of an appearance mimetic of the orange-brown and whitish *Tirumala formosa*, and probably leading also to the darker *T. mercedonia*. In the more western race *schultzei*, Auriv., from the N.E. Congo State, the outer edge of the male fore-wing is straight and it is nearly so in *abyssinicus*. In *franciscae* it is markedly curved and in *rex* strongly so, in this respect closely resembling the male model. In *schultzei* there is on the fore-wing above no trace of the orange-brown which is just indicated in *abyssinicus*, and, becoming more strongly marked in *franciscae*, reaches its fullest development in *rex rex*.

As Prof. Poulton pointed out (*ibid*., p. xliv), the mimicry of *T. formosa* obviously began with the strong orange marking at the costal margin of the base of the hind-wing under surface.

2. (**Papilio dardanus,** Brown, ♀ f.m. **planemoides,** Trim.)

P. dardanus, to my great disappointment, was not seen in Didinga : I had hoped to find forms which might be transitional between *dardanus hodsoni*, Poult. (*Proc. Ent. Soc*., 1925, p. xlvi–xlix) and the East African or Uganda races. N —, A—.

A single *planemoides* female, in the Imatong collection, extends the known range of this form (see *Proc. Ent. Soc*., 1925, pp. xiv-xv). It is very interesting

to record the presence of its model, *Planema poggei nelsoni*, Gr.-Sm., from the same locality as well as Didinga.

3. **Papilio nobilis,** Rghfr., subsp. nov. **didingensis.** (Pl. III, fig. 1, ♂; fig. 2, ♀.) I —, A —, N —.

Plentiful in Didinga.

Male.—The darker band, running along the costal margin outwards from the base of the fore-wing upper surface, is very much more heavily marked than in average specimens from Kenya or the west coast of L. Victoria. The markings of the hind-wing are extremely variable.

Female.—The accentuation of the costal band on the fore-wing is still more strongly marked in all specimens, and, in two of them, its extremity in the cell forms a definite patch of an intense blackish brown, as in the type specimen (Pl. III, fig. 2). The hind-wing differs from that of specimens from elsewhere in having the dark spots along the veins, just internal to the dark marginal band, less strongly marked.

Type.—A female, taken 25.xii.1925 (Pl. III, fig. 2), in the Hope Collection. Paratypes have been given to the National Collection and to the collections at Tring and Witley.

This species is difficult to catch except when fluttering at flowers or drinking from mud: 8 ♂♂ and 4 ♀♀ were secured. They were compared with a fine series of 20 ♂♂ and 5 ♀♀ mostly captured by Canon Rogers in Kenya Colony, and with 17 ♂♂ and 2 ♀♀ captured by myself at Kakindu on the west coast of L. Victoria close to the southern border of Uganda. In two specimens from Nairobi the dark costal band approaches that of the Didinga specimens, but has not the heavily accentuated tip characteristic of the new form. In the more western area of distribution the dark costal bar may be only faintly recognisable. The female *didingensis* reminds one of the appearance of the non-mimetic female of *P. dardanus hodsoni*.

4. **Papilio phorcas ansorgei,** Rothsch. I +, N —, A —.

The nine males appear to be of this Eastern race, which differs from the Western *p. phorcas*, Cr., in the absence of the discal spot in cellule 5 of the fore-wing, and by the presence of submarginal spots. One specimen shows a trace of this spot in cellule 5 on the left side. Two specimens from the Imatong Mountains agree with these. No yellow females (*thersander*, F.) were seen.

5. **Papilio nireus lyaeus,** Dbl.

These specimens (5 ♂♂ and 1 ♀) differ slightly in the ♂ armature from three taken by Kent-Lemon at Torit and in the Lakoia Hills, a little North of the Imatong Mountains, and from the Abyssinian specimens sent by Hodson, all of which—both Kent-Lemon's and Hodson's—have been determined by Dr. Jordan as *P. n. pseudonireus*, Feld. The Didinga *lyaeus* also differ from a series of 25 specimens taken by Wilson in the Nuba Mountains, and belonging to a race described in 1926 by Lord Rothschild as *P. wilsoni*, with ♂ armature similar to *pseudonireus*. The most interesting feature in this record is the light thrown upon the relative distribution of the three subspecies. The upperside patterns are very similar, especially so between the examples from Didinga and Abyssinia and between Imatong and the Nuba Mountains. There is, however, much variation and a longer series from Didinga and from Imatong may throw fresh light upon these comparisons.

6. **Papilio demodocus,** Esp. I +, N +, A +.

7. (**Papilio pylades pylades,** F.) The Northern race.

8. (**Papilio leonidas leonidas,** F.)

9. (**Papilio policenes,** Cr.)

PIERINAE.

10. **Leptosia (Nychitona) medusa,** Cr. I +, N —, A +.

The spot on the fore-wing is only present, and faintly marked, in two specimens out of the eight from Didinga. Two of the Abyssinian specimens out of the seven have the spot well marked, but it is not present in the two from the Imatong Mountains.

11. (**Herpaenia eriphia,** Godt.)

12. (**Mylothris chloris,** F.)

It is curious that this species, abundant in the Kent-Lemon and Wilson collections was not seen in Didinga.

13. **Mylothris rüppelli,** Koch, subsp. nov. **septentrionalis.** (Pl. II, fig. 3, ♂; fig. 4, ♀.)

Dr. Dixey found this to be " an interesting form." 15 ♂♂ and 11 ♀♀ were secured in excellent condition. I —, N —, A —.

This Northern race of *rüppelli* is distinguished by broadening and accentuation of the black tip to the fore-wing which, in the male, often extends back to vein 3, becoming continuous with a large black spot on vein 2 : in the female the black margin is always continued back to vein 2 and joins a large spot on vein 1. On the hind-wing there is on each vein a strongly developed marginal black spot, larger in the female. The pattern of the female is also different from that of the typical form; for the orange-yellow does not extend so far over the surface of the wings, but is restricted to a basal patch only slightly larger than that of the male.

Type.—A female, taken 5.i.1926 (Pl. II, fig. 4), in the Hope Collection. Paratypes have been given to the National Collection and to the collections at Tring and Witley.

It is remarkable that this species does not occur in the Kent-Lemon or Wilson collections, whereas the *chloris* in those collections was not found in Didinga. This species was not taken by Hodson in Abyssinia.

14. **Mylothris sagala jacksoni,** E. M. Sharpe. I —, N —, A —.

The 32 specimens are fairly heavily marked with black, but not so much as in the form *neumanni,* E. M. Sharpe, into which they are transitional.

15. (**Appias perlucens,** Btlr. = **Phrissura sylvia,** Auriv.)

16. **Appias (Glutophrissa) epaphia,** Cr. I +, N +, A +.

17. **Pieris (Belenois) raffrayi,** Oberth. I —, N —, A +.

This beautiful species was extremely abundant and in perfect condition : I found it hard to resist collecting more specimens than were needed ! The lustre on the coal-black border gives it almost a blue-black appearance on the

wing. A single specimen taken at Kakindu, on the southern frontier of Uganda, west of L. Victoria, and thirteen sent by Hodson from S.W. Abyssinia agree with the twenty-three from Didinga, as also do five specimens taken from Northern Bugishu, Uganda, on the foothills of Mt. Elgon.

A series of eight specimens taken by Dr. V. G. L. van Someren at Meru, N. Kenya, shows remarkable differences.* The black part of the wings has not the lustrous coal-black quality described above, being of a brownish tint. The under surface of the white parts of the wings is strongly suffused with yellow, which is less marked and only faintly yellowish on the upper surface. In the female the fore-wing is orange-yellow beneath. In the yellow suffusion these specimens of *raffrayi* approach *margaritacea*, E. M. Sharpe, but unlike the latter have no pale streaks in the black apex of the fore-wing, in this agreeing with the *raffrayi* from Didinga.

A single male, taken at Lumbwa, Kenya Colony, by H. L. Andrews, more nearly approaches *margaritacea*, having small pale streaks in the apex of the fore-wing. The black margin of the hind-wing is narrower than in *raffrayi*.

18. (**Pieris (Belenois) gidica,** Godt.)

19. **Pieris (Belenois) severina,** Cram. I +, N —.

20. **Pieris (Belenois) mesentina,** Cram. I +, N +.

21. **Pieris (Belenois) zochalia,** Boisd. I +, N +.

These are of the Eastern form. Of the four females taken in Didinga one has yellow, one orange, hind-wings.

22. **Pieris (Belenois) calypso,** Drury.

Two females only were taken, on which Dr. Dixey had noted that they were "an interesting form." They differ from typical examples in being much less heavily marked with black, and in the reduced size of the spots on the under surface. Kent-Lemon took a normal male and female, but none were sent from the Nuba Mountains.

23. **Pieris (Belenois) thysa,** Hpff. I +, N —.

24. **Pieris (Pinacopteryx) pigea,** Bdv. I —, N —.

25. (**Pieris (Pinacopteryx) venata,** Btlr.)

26. **Teracolus calais,** Cr. I +, N —.

27. (**Teracolus vesta mutans,** Btlr.)

28. **Teracolus protomedia,** Klug. I +, N +.

29. (**Teracolus celimene,** Luc.)

30. (**Teracolus eris,** Klug.)

31. (**Teracolus ione phlegyas,** Btlr.)

32. **Teracolus hetaera,** Gerst. I +, N —.

* This Meru form is described as *Pieris margaritacea somereni* by Mr. G. Talbot in *Bull. Hill Mus.*, II, No. 1, p. 29, 1928.

33. **Teracolus elgonensis glauningi,** A. Schultze. (Pl. III, fig. 3, ♂; fig. 4, ♀.) N —, A —.

Six males and a female, and a single male from the Imatong Mountains are of this Western race, described from the Cameroons. This is a heavily marked race, the black at the apex of the fore-wing forming a border completely enclosing the red spots and thinning away posteriorly so as just not to reach vein 2. A specimen from Toro district in Western Uganda, taken by C. A. Wiggins, nearly approaches this form. In the East African race there is very little or no black at the apex of the fore-wing, the red spots being free. In a long series from the locality west of L. Victoria, already cited as Kakindu, the amount of black varies from only a little more than in the Eastern race to a very heavily marked female in which there is a broad black border continued to the posterior angle and connected by a few scales with a separate spot in cell 1*b*. A single specimen from West of the Nile in the Northern Province of Uganda (West Nile District) shows more black than the Eastern forms, but not so much as specimens from Didinga. Three specimens from Northern Bugishu (Northern foot-hills of Mt. Elgon) are of the Western race *glauningi*, as in Didinga.

34. **Teracolus eupompe,** Klug. I —, N +.

35. **Teracolus achine,** Cram. I +, N +.

36. **Teracolus evippe,** L. I +, N +.

37. **Teracolus evagore,** Klug. I +, N +.

38. **Teracolus evarne,** Klug. I +, N +.

39. (**Eronia cleodora,** Hbn.)

40. (**Eronia leda,** Bdv.)

41. **Eronia (Leuceronia) thalassina,** Boisd. I +, N —.

42. **Catopsilia florella,** Fabr. I +, N +.

43. **Terias senegalensis,** Bdv. I +, N +.

44. **Terias desjardinsi regularis,** Btlr. I +, N —.

45. **Terias brigitta,** Cram. I +, N +.

The few specimens of these three *Terias* captured in Didinga were rather on the "wet" than on the "dry" side, thus contrasting with the species of *Precis*.

46. **Colias electo,** L. I —, N —.

Scarce, only one female having been captured.

Considering the Pierines as a whole it is worth recording that *Teracolus* and other open-country forms were scarce in Didinga as compared with the Imatong collection. Not only were species few, but very few individuals were taken, although the bush country at the foot of the mountains abounded in *Teracolus*. The long grass alternating with dense forest on the Didinga plateau (see Plate I) is certainly not the type of country in which *Teracolus* abound, and possibly the Imatong Mountains differ in this respect.

Danainae.

47. Danaida chrysippus, L.

Present in all its forms in all the four collections. The small size of many specimens, especially from the Imatong Mountains, is very noticeable.

The proportions of the four main forms are as follows:—

	Typical.	*alcippus*, Cr.	*dorippus*, Klug.	*albinus*, Lanz.
Didinga . . .	7	4	17	1
Imatong . . .	23	9	9	5
Nuba* . . .	17	34	4	10
S.W. Abyssinia . .	10	11	13	5

48. Tirumala petiverana, Dbl. & Hew. I +, N +, A +.

Only one specimen was seen, but not caught, in Didinga.

49. Tirumala formosa, Godm. I —, N —, A +.

A single specimen from Didinga proved to be very interesting, as it is transitional from the typical East African form to the Abyssinian race *neumanni*, Rothsch., specimens of which were sent by Hodson. This is characterised by having the orange-brown considerably darker than in the type. In the Didinga specimen the colour of the orange-brown is not so dark as in *neumanni*, though decidedly darker than in the type. The darkening of the orange-brown has continued still further in the species *T. mevedonia*, Karsch., of Uganda.

50. Amauris niavius, L. I —, N —, A +.

14 ♂♂ and 7 ♀♀ in excellent condition were taken, and proved to be interesting transitions towards the Abyssinian race *aethiops*, R. & J., which the specimens sent by Hodson from S.W. Abyssinia closely approach.

The subspecies *aethiops* is characterised by the narrowing from side to side of the large oblique, apical, white patch and by its smaller dimension in the long diameter, so that it does not approach so nearly to the outer margin of the wing. Hodson's specimens (see *Proc. Ent. Soc.*, 1925, p. li, pl. D, fig. 7) show a narrowing of this patch in varying degrees, but not so markedly as in typical *aethiops*, and the patch is only slightly shorter in its greatest diameter. The Didinga specimens come very near to Hodson's, but the variation from *n. niavius* is to a smaller degree. On the whole they are of Western type, as shown by the smaller size of the spots on the fore-wing and of the basal patch of the hind-wing, which in the Southern and Eastern race *dominicanus*, Trim., extends considerably beyond the distal end of the cell. The subjoined table, including all the Didinga specimens, gives the relative size of the white basal patch under four heads, showing at a glance whether its periphery does or does not reach to or beyond the end of the cell.

Just failing to reach end of cell.	Just reaching to end of cell.	Reaching just beyond end of cell.	Reaching well beyond end of cell.
♂ 5, ♀ 1	♂ 2, ♀ 3	♂ 2, ♀ 3	♂ 5

51. (Amauris echeria jacksoni, E. M. Sharpe.)

The *echeria* from Abyssinia are of the race *stevensi*, Klell.

* The numbers recorded in *Proc. Ent. Soc.*, 1924, p. lxxi, are: 20 *chrysippus*, 36 *alcippus* various degrees of white in H.W., 5 *dorippus*, 9 *albinus*.—E. M. S.

52. **Amauris lobengula,** E. M. Sharpe, subsp. nov. **mongallensis.** (Pl. III, fig. 5, ♂.) N —, A —.

A ♂ specimen from the Imatong Mountains agrees with another from Didinga in the characters described below.

This new geographical race *mongallensis* was first taken by Kent-Lemon. It comes nearest to the race *katangae*, Neave, in having white spots on the fore-wings and the yellow basal area of the hind-wing much narrowed at the costal margin. This patch is also of deeper ochreous tint than in *l. lobengula*. It is somewhat remarkable that this new Northern race should have its affinities more with the Southern race *katangae* than with the Northern race *septentrionis*, Poult., collected by V. G. L. van Someren at Marsabit, S.E. of Lake Rudolph, which has an altogether different appearance (*Proc. Ent. Soc.*, 1924, p. xxvi). The Didinga race of *lobengula* has a remarkable general resemblance to *Amauris echeria jacksoni*, E. M. Sharpe, the race of that species which has been taken in the Imatong Mountains though not in Didinga. These 8 males and 4 females of *e. jacksoni* show a considerable approach in the hind-wing to the Abyssinian race *steckeri*, Kheil, the pale patch being contracted to a varying degree. Specimens can be found from Nyangori near Kisumu in Kenya Colony which match the Imatong series.

The Didinga specimen of *mongallensis* is taken as the type of the race, since it has the distinguishing characters more developed than the Imatong specimen.

Male.—Fore-wing.—On the Upper Surface all the markings white, and the two chief spots, one in the cell, one in area 2, smaller than in *katangae*. The spot in the cell is much narrower in proportion than in *katangae*, but does not quite reach the posterior border of the cell, while the broader spot of the southern race just touches the posterior border. The strongly concave outer border of the spot is much less concave in *mongallensis*, and this feature is more pronounced in the Didinga specimen in which this spot is nearly parallel-sided. The spot in area 2 is also narrower transversely than in *katangae* and this feature again is better shown in the Didinga specimen. The row of marginal spots is more conspicuous than in *katangae*, which has one in area 2 and two in area 3. In *mongallensis* there are—in area 2, an additional smaller posterior spot; in area 3, two spots as in *katangae*; in area 4, an additional spot close to vein 4. The row of submarginal spots is also increased by one in area 4.

On the Under Surface the marginal spots are much more strongly marked than on the upper and, from area 1*b*, are continued forward into area 7: this is not so in *katangae*, which only shows one extra spot in area 4 (the one described as visible on the *upper* surface in *mongallensis*), and one in area 7.

Hind-wing.—On the Upper Surface the yellow basal area is even narrower anteriorly at the costal margin than in *katangae*, in which it is narrower than in *l. lobengula*. Thus in the latter it extends as far beyond the origin of vein 7 towards the base of the wing as it does towards the margin, while in some specimens it extends even further towards the base. In *mongallensis*, however, it terminates proximally at the origin of vein 7, thus producing a resemblance to *echeria jacksoni*. Posteriorly the yellow basal area just fails to reach the anterior end of the male brand, so that the black border of the hind-wing is broader than in *katangae*. There is a definite row of minute yellowish marginal spots, absent in *katangae*, and the row of submarginal spots is more complete than in the latter. Furthermore, these spots are of the same colour as the yellow basal area, whereas in *katangae* they are white in area 3, faintly yellowish in area 1.

On the Under Surface the rows of marginal and submarginal spots are complete, and are white, not yellow as on the upper surface. In this respect there is no essential difference from *katangae*.

Type.—A male taken 26.xii.1925 (Pl. III, fig. 5) in the Hope Collection, with one male paratype from the Imatong Mountains.

An interesting specimen of *lobengula*, a female, was taken in December 1925 at Agoro camp, in Uganda, at the base of the mountain range, there called Agoro, but in the Sudan called the Imatong Mountains. It may be transitional between *mongallensis* and the typical form of *lobengula* or the differences between it and the male type of *mongallensis* may be the minor differences of sex, in which case this specimen would be the female of *mongallensis*. More material is required before this point can be decided. The cellular spot of the fore-wing is nearly as in *katangae*. A minute spot which, in *mongallensis*, is interposed between the proximal spot in area 4 and the spot on the costal margin in front of it, is much larger than in *mongallensis*, as also is the latter of the two spots mentioned. The row of marginal spots is more complete than in *mongallensis* or in *katangae*. On the hind-wing the yellow basal area extends as far outwards as in *katangae* (*i.e.* further than in the males described above as *mongallensis*), but its anterior border is more irregular and indented than in *katangae* or the two males. At its costal margin this area is as broad as in *katangae*, and thus broader than in the two males. The row of marginal spots (absent in *katangae*) is as in the males, and, as in these also, the submarginal spots are large and form a complete row. On the under surface they are white, except the two innermost in area 7, which are yellow, in this respect differing from the other specimens here described.

Satyrinae.

53. **Melanitis leda,** L. I +, N +, A +.

The single specimen taken in Didinga was of a fairly " wet " form. Seven specimens taken by Kent-Lemon between Aug. 15th–Sept. 2nd were " wet " forms: the long series from the Nuba Mountains contains both " wet " and " dry " forms.

54. **Melanitis libya,** Dist. I +, N —, A +.

Three specimens with marbled underside and no distinct eye-spots are of the " wet " form.

55. (**Gnophodes parmeno,** Dbl. & Hew.)

56. (**Mycalesis mandanes,** Hew.)

57. (**Mycalesis safitza,** Hew.)

58. (**Mycalesis miriam,** Fab.)

59. (**Mycalesis pavonis,** Btlr.)

60. (**Mycalesis campa,** Karsch.)

61. (**Mycalesis smithi,** Auriv.)

62. (**Mycalesis anynana,** Btlr.)

63. (**Mycalesis vulgaris,** Btlr.)

64. (**Mycalesis angulosa,** Btlr.)

65. (**Mycalesis saussurei,** Dew.)

66. **Henotesia perspicua,** Trim. I +, N +, A +.

Kent-Lemon took this species on both the Imatong Mountains and on the Lafiet Mountains further north. Of the four specimens from Didinga one is of the dry form *maevius*, Stgr., and three are intermediates. Two of the specimens have the spot in cellule 3 surrounded by a square red-brown patch. In another specimen the red area is decidedly quadrangular and around the spots in cellules 2 and 3 there is a considerable suffusion with red which extends to vein 5 at about the middle of the wing. None of the six specimens from the Nuba Mountains nor the ten from Abyssinia show this quadrangular patch, but it is present in the Lafiet specimen.

67. **Neocenyra gregorii,** Btlr.

This was the only common small Satyrine taken in Didinga. Kent-Lemon did not find it on the Imatong Mountains, but sent it from Lafiet Mountains. None from the Nuba Mountains.

68. (**Ypthima impura,** Btlr.)

69. (**Ypthima asterope,** Klug.)

70. (**Ypthima itonia,** Hew.)

71. (**Ypthima albida,** Btlr.)

The Didinga Satyrines contrast remarkably as regards "wet" or "dry" appearance with the *Precis* taken at the same time, but it is noteworthy that the few Pierines were also not very "dry" in character.

NYMPHALINAE.

72. **Charaxes jasius epijasius,** Reiche.

A battered specimen agrees with a long series from I, N, and A, in being of the typical form *epijasius*.

73. **Charaxes brutus brutus,** Cr. I —, N —.

Five specimens from Didinga are not of the race *somalicus*, Rothsch., taken in Abyssinia, of which Hodson sent ten specimens. *Somalicus* has a narrower, yellow band, and marginal brown crescentic marks well developed on the hind-wing.* The Didinga specimens have rather narrow bands which in four seem decidedly tinted with pale yellow. Three specimens are without marginal markings, but one has a trace of bluish marks on the hind-wing. The fifth white-banded specimen has a trace of brownish marginal markings. Thus the Didinga specimens are very slightly transitional towards the Abyssinian and Somali race.

74. **Charaxes castor castor,** Cr. I +, N —, A +.

The Imatong specimen is too battered to be definitely diagnosed, but the Didinga and Abyssinian (four) specimens are of the Western race.

* See E. B. Poulton, "Mimicry in African Butterflies of the genus Charaxes," III Internationaler Entomologen-Kongress, Zürich, July 1925, Band II, p. 537.

75. **Charaxes hansali baringana,** Rothsch. I —, N —, A —.

A single female agrees well with the Eastern race *baringana* taken by Rogers at Taita, Kenya Colony, except that the spots on the fore-wing in areas 3, 4, 5, are strongly marked.

76. **Charaxes pollux pollux,** Cr. I —, N —, A —.

A single specimen, of the Western race, was taken in Didinga.

77. **Charaxes boueti rectans,** R. & J. I +, N —, A +.

The single male of this Northern form, as compared with two from the Imatong Mountains, is somewhat yellower in the general ground-colour on the under surface and the silver band on the fore-wing is less strongly marked.

78. **Charaxes smaragdalis orientalis,** Joicey & Talbot. I —, N —, A —.

A somewhat damaged specimen of the Eastern race of this Western species.

79. **Charaxes tiridates,** Cr. I +, N —, A +.

Thirteen males were taken in Didinga, one in the Imatong Mountains and one in Abyssinia. The mimetically associated *numenes*, Hew., was taken in Abyssinia, but in no other of these localities.

80. **Charaxes baumanni,** Rghfr. I —, N —, A —.

Six males from Didinga seem quite typical; the single female has the white band slightly narrowed, especially on the fore-wing.

81. (**Charaxes etheocles violae,** Butl.)

Taken in the Imatong and Nuba Mountains, together with the usual female form (see *Proc. Ent. Soc.*, 1919, p. lxxvii; *ibid.*, 1920, p. xxiv).

82. (**Charaxes ethalion,** Bdv.)

83. **Charaxes candiope candiope,** Godt. I —, N —, A +.

The specimens seem quite typical.

84. (**Charaxes varanes vologeses,** Mab.)

85. (**Charaxes zoolina,** Westw.) A +.

Two specimens taken in May 1919, both of the "wet" form *zoolina*. Both forms are present in the Abyssinian collection.

86. **Charaxes eupale,** Drury. I —, N —, A —.

Eight normal specimens were taken in Didinga.

The complete absence of the great genus of **Euphaedra** and its near allies from the three localities in the Sudan is made the more interesting by the presence of *Euphaedra neumanni*, Rothsch., in the Hodson collection from Abyssinia. It appears to be common.

87. **Hamanumida daedalus,** F. I —, N +, A +.

A single (typical) specimen was sent from Didinga for record. The species was not uncommon, but precious time was not wasted over the pursuit. The long series from the Nuba Mountains contains fourteen normal forms; twelve

others have the white spots very distinct beneath as in form *meleagris*, Cr., but the ground-colour is often darker than in that form. Thirteen specimens from Abyssinia are normal, four of the form *meleagris*.

88. (**Aterica galene,** Brown.)

The typical mimetic form with white hind-wing patch.

89. **Pseudacraea boisduvali,** Dbl. I —, N —, A +.

Two males and two females were taken in Didinga. On the whole they are nearer the Western race *boisduvali*, Dbl., though the orange of the Eastern and Southern race *trimeni*, Btlr., is represented by a well-defined subapical patch in the males, better marked in one of the two. The two females are more Western than the males, and one female secured by Hodson is much nearer the typical Western form. It is of interest that one of the models for this species, *Acraea zetes*, taken in Didinga, is also of rather Western appearance. See No. 133. (The models of *boisduvali*, and its forms, are dealt with in *Trans. Ent. Soc.*, 1913, pp. 646–655.)

It is worth recording that *Pseudacraea eurytus*, L., is apparently absent from Didinga, the Imatong and Nuba Mountains. Hodson, however, sent the forms *terra*, Neave, and *tirikensis*, Neave, from S.W. Abyssinia.

90. (**Pseudacraea lucretia,** Cr.)

91. **Neptis saclava marpessa,** Hpffr. I +, N —, A +.

92. **Neptis agatha,** Stoll. I +, N +, A +.

It is a curious fact that these two were the only species of *Neptis* taken in the three localities in the Sudan, and in Abyssinia.

93. (**Cyrestis camillus,** F.)

94. (**Crenis occidentalium,** Mab.)

95. **Crenis boisduvali,** Wllgrn. I —, N —.

Two specimens from Didinga were typical; three from Abyssinia were of the race *kaffana*, R. & J.

96. **Crenis garega,** Karsch. (= **ansorgei,** Rothsch.). I —, N —, A +.

97. **Byblia illythia,** Drury. I +, N +, A +.

98. **Byblia acheloia,** Wllgrn. I +, N +, A +.

The single Didinga specimen is of the " wet " form *vulgaris*, Stgr. A long series from the Imatong and Nuba Mountains are " dry." Five of the Abyssinian specimens are " wet," three " dry."

99. **Neptidopsis ophione velleda,** Mab. I —, N —, A +.

The two from Didinga are characteristically of the Eastern race. A long series from Abyssinia contains three similar specimens, and ten in which the Eastern character is not quite so strong.

100. **Eurytela hiarbas lita,** R. & J. N —, A +.

Twenty-three specimens from Didinga, where the butterfly was very common, all agree in being of the Eastern race with narrowed white band only

reaching vein 4, the fore-wing very obtusely angled and the hind-wing not sharply dentated. Nine specimens from Abyssinia agree with these, but the single specimen from the Imatong Mountains appears to be of the Western race *hiarbas*, Drury, which is extremely interesting in a locality so near to Didinga. More specimens are much wanted.

101. **Eurytela dryope angulata,** Auriv. I +, N —, A +.

All nine specimens are of this Eastern race.

102. (**Kallima jacksoni,** E. M. Sharpe.)

103. **Hypolimnas misippus,** L. I +, N +, A +.

The subjoined table of the numbers of the different forms of female is of interest as compared with the similar table for *D. chrysippus* (p. 34).

	Typical.	*alcippoides*, Btlr.	*inaria*, Cr.
Didinga	5	1	4
Imatong	4		2
Nuba	6	1	5
S.W. Abyssinia . .	4		1

104. (**Salamis temora,** Btlr.)

105. **Salamis parhassus aethiops,** Pal. I +, N —, A +.

All specimens are of this Eastern and Southern form.

106. (**Catacroptera cloanthe ligata,** R. & J.)

The specimens taken by Kent-Lemon are nearer this North-western race than the South-eastern *cloanthe*, Cr.

107. **Precis chorimene,** Guèr. I +, N +, A +.

Thirteen specimens were taken in Didinga, where the species was plentiful. Seven of the specimens have the underside marbled, with well-developed eye-spots. The other six of a " dry " tendency are not quite the form *angulata*, Auriv., of Abyssinia since they do not have the " distal margin of the fore-wing much more produced at vein 6, and the upper surface darker." They vary in the development of the eye-spots and of the white spot on the under surface of the hind-wing at the costal edge of the dark line, and they have the under surface more uniform and less strongly marbled, with the angle of the fore-wing slightly more hooked. In one small specimen the eye-spots have disappeared. A series of specimens from L. Victoria, however, shows a range of variation equal to the above. The seven specimens from the Imatong Mountains and one from the Lafiet Mountains are all on the " wet " side. The latter was taken on June 14th, while, of the former, three were taken April 5th, two April 9th, one Sept. 4th, one Oct. 4th. Wilson sent twenty-one specimens from the Nuba Mountains, all of the " wet " form save one, taken on Oct. 5th, in which the eye-spots were not so well marked although the fore-wing is not hooked. These specimens were taken from May 24th–Oct. 7th. Hodson sent twelve specimen from Abyssinia, caught between Oct. 31st and Nov. 14th. Nine of them are of the same type as the six mentioned from Didinga, and one has the darker upperside, more strongly developed hook on the fore-wing, and lack of eye-spots which are the features characteristic of the form *angulata*, Auriv. Only two have the " wet " appearance with strongly marked eye-spots and fore-wing less hooked.

108. **Precis terea,** Drury. I +, N —, A +.

The three specimens from Didinga agree with fourteen from the Imatong Mountains in being decidedly Western in character. Fourteen specimens from Abyssinia are not quite so Western as the above. While the pale band is fairly broad and includes the dark line, there is anteriorly a broadening of the black margin which thus narrows the pale band and suggests transition to the Eastern race *elgiva,* Hew. In one specimen this transitional appearance is especially evident.

109. (**Precis limnoria taveta,** Rog.)

A single specimen taken by Kent-Lemon " west of the Lafiet Mountains."

110. **Precis archesia,** Cr. I +, N —, A —.

A most interesting series of forty-eight specimens from Didinga was captured almost entirely by beating them out from under the eaves of a deserted cluster of native huts in an open grassy space on the top of a bush-covered kopje. The series of *sesamus* described below was also taken by the same means, all within a few days. After the great catch only occasional specimens were taken, so that there appears to have been a definite gathering together at a favourable shelter. The great majority of specimens of both the species were in extremely fresh condition. One specimen taken on Dec. 25th is of the " wet " form *pelasgis,* Godt., and is an old, worn butterfly; another is very near the typical *pelasgis.* The remaining forty-six specimens present, on the upper surface, an extraordinarily uniform appearance which is more or less that of *semitypica,* Auriv., though rather on the " wet " side of that form. Reference may here be made to *Proc. Ent. Soc.,* 1918, pp. cxxv–cxxxi, where a series of forms captured in German East Africa by the writer was described by Prof. Poulton as *semitypica.* This form *semitypica,* following an intermediate called *staudingeri,* Dew., seems to come about mid-way in a series from the full dry form *archesia* to the full wet form *pelasgis.* In this series *staudingeri* is on the dry side, and *semitypica* on the wet. The forms described by Poulton, however, are rather " drier " than the Didinga specimens, which thus seem to come between *semitypica* and the full wet *pelasgis.* These Didinga examples show, on the upper surface, a strongly-marked red transverse band combined with complete absence of blue. On the under surface they are more variable, and tend more towards the marbled appearance of the procryptic dry form *archesia,* though the pale transverse band is fairly well marked. The shape of the fore-wings is rather that of *archesia* than *pelasgis,* the hook being well developed.

To sum up, these Didinga specimens have the shape of the dry form, the under surface more dry than wet, the upper surface more wet than dry. They were taken in the height of the dry season. The eight specimens caught by Kent-Lemon on the Imatong Mountains from June 2nd to Sept. 9th are of the full wet form *pelasgis,* as they should be, according to the meteorological data for Didinga.

111. (**Precis pelarga,** F.)

112. (**Precis antilope simia,** Wallgr.)

113. **Precis octavia,** Cr. I +, N +, A +.

The forms *sesamus,* Trim., *natalensis,* Stgr., *octavia,* Cr., and *amestris,* Drury, must all be considered with reference to these collections.

Reference may be made to the *Trans.* and *Proc. Ent. Soc.* as follows :—

Trans., 1902, pp. 414–460 (general account, referring also to other species of *Precis*. The *sesamus* dealt with were from S.E. Africa, Kenya Colony and Uganda).

Proc., 1906, pp. lviii–lxix (dealing with a series from Kilimanjaro).

Proc., 1918, pp. cxxvii–cxxxii (dealing with a series from German E. Africa).

Proc., 1924, pp. xviii–xx (dealing with a series from Nairobi).

The form *natalensis* is the bright salmon pink wet season form of the Southern and Eastern race, whose dark blue dry season form is *sesamus*. Analogous Western forms are *octavia*, whose pink has not the rich salmon hue of *natalensis*, but is of a browner tint, and *amestris* with little or no blue at the base of the fore-wing, and, in the cell, one or two red-brown transverse streaks. The Western race occurs " from Sierra Leone to Congo, Abyssinia, and Somaliland " (Aurivillius in Seitz), and it will be seen that the collections under discussion show many Western features. Firstly, the Didinga specimens, taken as previously described, may be classified according to the following subheads.

A. *Amestris*, —1.

B. Near *amestris*, —1. This specimen agrees well with *amestris* in absence of blue from the base of the fore-wing, but has no red mark in the cell.

C. *Sesamus*, transitional towards *amestris*, —20. These have the blue at base of fore-wing less than in normal *sesamus*, and have a strong red mark in the cell.

D. *Sesamus*, with strong red mark in the cell, —22.

E. *Sesamus*, the red mark in the cell little developed, —16.

F. True Eastern *sesamus* with no red in cell, —1.

G. *Sesamus*, slightly transitional to *natalensis*, with strong red mark in the cell, —27.

H. *Sesamus*, strongly transitional to *natalensis*, with strong red mark in the cell, —12.

I. *Natalensis*, transitional to *sesamus*, —0.

J. True Eastern *natalensis*, rich salmon pink, —8.

K. *Natalensis*, tending towards browny pink of *octavia*, —0.

L. *Natalensis*, black basal markings of fore-wing tending towards pattern of *octavia*, —5.

M. True Western *octavia*, —0.

Considering these specimens first from the point of view of geographical forms, we may class A, B, C, K, L, M, totalling 27 specimens, as being strongly under Western influence, while D and E show Western influence to a smaller degree in the development of the red mark in the cell (38 specimens). Groups F, G, H, I, J, totalling 48, are of more Eastern type, though it is difficult to know whether the red mark in the cell in G and H is due to the transition towards the *natalensis* form or whether it is due to Western influence. If the latter, as seems probable in view of the large numbers under C, D, E, then only 9 specimens out of 113 are left of truly Eastern form ! Considered from the seasonal point of view these specimens contrast with the series of *archesia*, caught at the same time, in being much more definitely dry. Out of the 113 only I, J, K, L, M, totalling 13, are on the "wet" side. It is interesting to note that the transitions between extreme wet and dry forms were all from the dry side (*sesamus*) towards the wet (*natalensis*). Treating the series obtained in the Nuba Mountains by Wilson in the same way we arrive at the following figures :—

			J. 1.
A. 4.	D. 1.	G. 4.	K. 4.
B. 0.	E. 8.	H. 1.	L. 3.
C. 14.	F. 1.	I. 0.	M. 0.

Considering these 41 Nuba Mountains specimens geographically we find they are more strongly Western than those from Didinga. Taking the same methods as before, putting F and J as the really Eastern forms, we find only 2 out of 41 are truly Eastern, 39 being Western or showing Western influence. A difference from the Didinga series is shown under group K, in which the wet-season pink has the browner tint, tending towards *octavia*. None of these were taken in Didinga, whereas half of the *natalensis* on the Nuba Mountains were of this browner form.

Group L. requires a little explanation. Specimens of this type have the black patch at the base of the fore-wing extending forwards towards the costa to join, or at any rate nearly to join, the outermost patch of black in the cell. In *octavia* this union is complete to form a continuous bar, giving a characteristic appearance to the black basal patch. As regards the seasonal point of view, the Nuba Mountains specimens are accompanied by a note from Wilson that "rains began" (in 1924) in May and ended early in October. His specimens are in three sets, captured between mid-October 1904 and the end of February 1905; between May and December 1917, and between February and October 1918. The eight "wet" forms were captured as follows: 27.vii.17 (2), 3.viii.17, 4.viii.17, 29.ix.17, 17.v.18, "August" 1918, 7.x.18, which agree quite well with the dates given above for the Nuba rains. Of Wilson's 41 specimens only 4 were slightly transitional to *natalensis* and only 1 strongly transitional.

Only one specimen appears in the Kent-Lemon collection from the Imatong Mountains. This is a "wet" form, taken on Sept. 24th. Its pink is of a slightly brownish hue, not the bright salmon hue of the typical Eastern form. Thus a slight transition to *octavia* exists, but the black area at the base of the fore-wing is not that of *octavia*.

114. **Precis oenone cebrene,** Trim. I +, N +, A +.

115. **Precis clelia,** Cr. I +, N +, A +.

116. **Precis orithyia madagascariensis,** Guén. I +, N +, A +.

Judging by the numbers of specimens from Didinga, Nuba Mountains and Abyssinia this species is more abundant than the preceding. From the Imatong Mountains 6 were sent, against 9 *clelia*.

117. (**Vanessula milca,** Hew.)

118. **Pyrameis cardui,** L. I +, N +, A +.

119. **Antanartia abyssinica,** Fldr. I —, N —, A +.

120. **Antanartia hippomene,** Hbn. I +, N —, A +.

121. **Antanartia schaeneia,** Trim. I —, N —, A +.

The 11 males sent by Hodson approach the Abyssinian form *diluta*, R. & J., in having the band slightly narrower, and sometimes a marginal line along the half of the hind-wing near the tail. The single, rather worn, female has the fore-wing band whitish, as in the typical *diluta*. It is interesting to note that the

Didinga specimens are not transitional to the Abyssinian specimens. The almost complete absence of this genus from the Kent-Lemon collection is remarkable. It contains only a single specimen of *hippomene*. In Didinga all three species were very plentiful.

122. (**Atella phalantha,** Drury.)

123. (**Argynnis (Brenthis) hanningtoni,** Elwes.)

I was much surprised not to find this in Didinga.

ACRAEINAE.

124. **Planema poggei nelsoni,** Gr.-Sm. I +, N —, A —.

This is the only *Planema* taken in the Didinga and Imatong regions—two males in the former, one in the latter. None occur in the collection from Nuba Mountains, but three species were sent from Abyssinia. The species under discussion is of the Northern race, which is the form predominant in Uganda. (Ref. *Proc. Ent. Soc.*, 1925, pp. xiii–xv; Vol. II, 1927, pp. 37, 38.) The fact that the only female *dardanus* that has been taken in either the Imatong or Didinga Mountains is of the form *planemoides*, mimicking *poggei nelsoni*, is of considerable interest.

125. **Acraea ansorgei,** Gr.-Sm. (**conjuncta,** Gr.-Sm.), f. **interrupta,** Eltr. I —, N —, A —.

This was very abundant in the Didinga forests, but has not been sent from the other three localities. The 59 specimens taken in Didinga fall into three groups according to the depth of colour of the pale markings whose pattern is that of the form *interrupta*.

1. Cream.	2. Intermediate.	3. Dull orange.
♂ 13, ♀ 17	♂ 1, ♀ 8	♂ 17, ♀ 3

The cream variety is very near the form *mutata*, Eltr., but the apical spots are not quite white. The analysis above shows that more of the darker specimens are males, while the females tend to be paler, but sexual dimorphism is not complete. Comparison with what is said later about the Northern *lycoa* and *johnstoni* is of interest. Other specimens in the Hope Department were examined and confirm the above finding. There are no specimens like group 1, but of the dark forms 7 are males and 3 females. Two specimens of form *mutata*, Eltr., are male and female, while it is significant that both specimens of the white form *pica*, Eltr., are females. This species flew in the forests in company with *A. johnstoni* and the pale specimens (group 1) were remarkably like small specimens of the latter.

126. **Acraea johnstoni,** Godm. I +, N —, A +.

Extremely plentiful in Didinga, where 144 specimens were taken, but only a single specimen occurs in the Imatong collection and one was sent from Abyssinia. The species was not sent from the Nuba Mountains. The Didinga series presents features of great interest. On separating those of the form *flavescens*, Oberth., with all the spots pale yellow, from those of the form *confusa*, Rogenh., with the spots on the fore-wing white instead of yellow, I found that the former (48) were *all males*, while the latter (67) were *all females*. The species thus has

become completely sexually dimorphic in Didinga, and may be contrasted with its near relative *lycoa*, Godt., in Abyssinia, which has there become monomorphic, male and female alike, the form *aequalis*, R. & J.

This sexual difference between the spots on the fore-wing holds good in other forms of *johnstoni* captured in Didinga. Thus 4 males and 1 female have the spots as above but they are suffused round the edges with rich chestnut brown, which colour also occurs on the basal half of the fore-wing: the pale area of the hind-wing is of the same chestnut brown.

Six other males and 18 females are of the form *semialbescens*, Oberth., in which the fore-wing spots are different in the sexes as above, but without chestnut suffusion, although the patch on the hind-wing is of the same chestnut brown. These 24 specimens present an extraordinarily uniform appearance. Prof. Poulton very kindly examined for me the specimens of *semialbescens* in the National Collection, and found that the 4 males and 3 females all came from Nyasaland. The great distance between the two habitats is of considerable interest. The females and one male resemble the Didinga specimens, but 3 males differ in the following points. The chestnut colour of the hind-wing runs out in radiate streaks towards the margin in the anal half of the wing, the darker ground-colour remaining as dark internervular streaks. Also in 2 of these 3 males there are dark, inconspicuous, chestnut streaks along the chief veins in the basal section of the fore-wing.

Another form is *octobalia*, Karsch. This is similar to *semialbescens*, but the four spots on the fore-wing are yellow and the above-described radiate chestnut marking appears in a variable degree of development in the 2 females as well as the 4 males in the National Collection. Eltringham gives Mpwapwa, Tanganyika Territory, as the locality for *octobalia*. The single specimen of *johnstoni* sent from the Imatong Mountains is a female of the form *confusa*. A single male sent from Abyssinia is probably the form *flavescens* with the spots yellow, but, being very worn, it cannot be classed with certainty.

127. **(Acraea encedon,** L.)

Type, and form *lycia*, F., from the Imatong Mountains.

128. **Acraea oreas oreas,** E. M. Sharpe. I +, N —, A —.

Very abundant in Didinga. The form *albimaculata*, Neave, was not uncommon but at the time was mistaken for worn specimens of the yellow-spotted form, so that only one occurs in twenty-three specimens from Didinga. The specimens cannot be ascribed to any definite geographical race (see Eltringham, *Trans. Ent. Soc.*, 1912, p. 300). The marginal ground-colour of the under surface is of every shade from bright golden yellow to deep brown. Two specimens from the Imatong Mountains have the margin dark brown beneath.

129. **Acraea cabira cabira,** Hpff. I +, N —, A —.

Among the sixteen specimens from the Imatong Mountains is a variety in which, on the hinder part of the fore-wing, the yellow spot is sharply cut in two by darkening along vein 2, and on the costal margin of the hind-wing the yellow band is replaced by black as far back as vein 6.

130. **Acraea terpsichore,** L. I +, N +, A +.

The form *rougeti*, Guér., is predominant in Didinga and the Imatong Mountains, but the female form *janisca*, Godt., occurs. One male from Didinga has the marginal black band almost solidly black, with only faintly-marked

orange streaks. The specimens from the Nuba Mountains show typical *terpsichore* and transitions to *rougeti*, together with typical *rougeti* and *janisca*. The Abyssinian specimens are of varied form, but mostly transitional between *terpsichore* and *rougeti*; true *terpsichore* and *janisca* occur. A striking series of 15 specimens, taken on Sept. 15th, 1925, in the Maji province at 7700 feet, is of the form *ventura*, Hew., with strong development of red below, while there are also transitions from this form to the type.

131. (**Acraea natalica abadima,** Ribbe.)

132. **Acraea caecilia,** F. I —, N +, A —.

Two females taken in Didinga are on the whole Western in their appearance rather than the Eastern *pudora*, Auriv., in which the apical black area on the fore-wing is rather narrower. One of the specimens is of quite an intense salmon-pink all over, not only on the hind-wing as in the true Western *hypatia*, Drury. The other is of a more usual brownish hue with slight whitish suffusion in the centre of the hind-wing. The collection from the Nuba Mountains has 53 of form *caecilia*, 9 females of the Western *artemisia*, Stoll, in which the ground-colour is whitish and the black markings widened, and 3 near to *artemisia*.

133. (**Acraea doubledayi sykesi,** E. M. Sharpe.)

This species is abundant in the Imatong and Nuba collections, so that its absence from Didinga is surprising. It was not sent from S.W. Abyssinia.

34. (**Acraea pudorella pudorella,** Auriv.)

This species takes the place of *caecilia* in the Imatong and Abyssinian collections. The former contains 6 ♂♂, 4 ♀♀, including three pairs taken *in coitû*.

135. (**Acraea cepheus,** L., trans. to **abdera,** Hew.)

136. (**Acraea perenna,** Dbl.)

137. (**Acraea egina,** Cr.)

138. (**Acraea pseudolycia astrigera,** Btlr.)

139. **Acraea zetes,** L. I +, N —, A +.

Four females were taken in Didinga. Two, rather old, and one of them of small size, seem to be of the form *jalema*, Godt., intermediate between the Western *menippe*, Drury, and the Eastern *acara*, Hew. They have no basal black on the fore-wing, but have well-marked spots on the margin of the hind-wing. The ground-colour of the fore-wing is rather brownish pink, the subapical bar slightly yellowish. The other two specimens, in fresh condition, have the ground-colour of much richer pink; indeed in one it is as rich as that of the male. In both, the subapical bar and marginal spots on the fore-wing are a pronounced orange. These two examples are thus strongly Eastern in appearance. Dr. V. G. L. van Someren has sent a brilliantly coloured male and female from Marsabit, in the northern part of Kenya Colony, and a similar specimen of each sex from Meru. In this form the male and female are closely alike. These latter specimens are of great interest as transitional towards the wonderful *oscari*, Roths., of Abyssinia, in which the black spots are enormously increased in size and the ground-colour is of an extremely deep rich pink. Hodson sent 8 males and 3 females of *oscari* which is doubtfully a distinct species from *zetes*, and also a male and female of *jalema*, whose male is richly pink but

with spots of normal size. Kent-Lemon collected in the Imatong Mountains 16 *zetes*, of which 4 males and 2 females are of form *jalema*, 9 males and 1 female of form *menippe*. This series therefore shows Western rather than Eastern affinities. It does not include any of the deeply coloured form transitional to *oscari*. The presence of *zetes* in Didinga gains added interest from the fact that its mimic, *Pseudacraea boisduvali* (No. 82) was also taken there, and is also of a rather Western form.

140. **(Pardopsis punctatissima,** Bdv.)

ERYCINIDAE.

141. **Libythea labdaca,** Westw. I —, N —, A —.

Extremely abundant in Didinga at the time of our visit.

LYCAENIDAE.

142. **Lachnocnema bibulus,** F. I +, N +.

143. **Deudorix dinochares,** Gr.-Sm. (= **licinia,** Trim.) I —, N +.

Kent-Lemon did not find this on the Imatong Mountains, but sent specimens from another part of the Mongalla Province, viz. "Lyria."

144. **Deudorix antalus,** Hpffr. I —, N +.

Kent-Lemon sent a long series from "Lyria."

145. **Lycaenesthes lemnos,** Hew. I —, N —.

146. **Lycaenesthes crawshayi,** Btlr., var. **minuta,** B.-B. I +, N +.

147. **Cupido (Uranothauma) falkensteini,** Dew. I +, N —.

148. **Cupido (Cacyreus) lingeus,** Cr. I +, N +.

149. **Cupido (Cacyreus) palaemon,** Cr. I —, N —.

150. **Cupido (Castalius) margaritaceus,** E. M. Sharpe. I +, N —.

The closely allied *cretosus*, Btlr., is apparently abundant in the Nuba Mountains, and was also present in the Imatong collection, so it is interesting to note that we did not find it in Didinga; whereas the preceding species, common in Didinga, was not sent from Nuba Mountains. Possibly the abundance of *margaritaceus* masked the presence of the other in Didinga.

151. **Cupido (Tarucus) telicanus plinius,** F. I +, N +.

152. **Cupido (Lampides) boeticus,** L. I +, N +.

153. **Cupido (Catochrysops) subpallida,** B.-B. I —, N —.

154. **Cupido (Euchrysops) osiris,** Hpffr. I —, N +.

155. **Cupido (Chilades) nandiana,** B.-B. I —, N —.

156. **Cupido (Zizera) gaika,** Trim. I +, N +.

157. **Cupido (Zizera) lucida,** Trim. I +, N —.

In addition to the species listed above there are many LYCAENIDAE in the Kent-Lemon collection which are not recorded from Didinga. Unfortunately

time was too short to enable me to identify these, but mention must be made of one particularly interesting species taken by Kent-Lemon, 28th April, 1917, at Talodi in the Nuba Mountains, viz., *Telipna bimaculata albofasciata*, Auriv. The presence so far north as Talodi of this typically Western genus (extending to Uganda) is especially worthy of note.

Hesperiidae.

As in the case of Lycaenidae the species of Hesperiidae in the Imatong collection which were not taken in Didinga are not listed here.

158. **Rhopalocampta anchises,** Gerst. I +, N —.

159. **Rhopalocampta forestan,** Cr. I +, N +.

160. **Padraona zeno,** Trim. I +, N —.

161. **Parnara mathias,** F. I +, N +.

162. **Gegenes niso,** L. (= **hottentota,** Trim.) I +, N —

163. **Parosmodes morantii,** Trim. I —, N —.

164. **Cyclopides trisignatus,** Neave. I +, N —.

165. **Acleros (Suastus) mackeni,** Trim. I +, N —.

166. **Carcharodus (Gomalia) elma,** Trim. I +, N +.

167. **Caprona (Netrobalane) canopus,** Trim. I +, N —.

168. **Tagiades flesus,** Fabr. I +, N —.

169. **Eagris lucetia,** Hew., subsp. nov. **obliterata.** (Pl. II, fig. 5, ♂; fig. 6, ♀.) I —, N —, A +.

The three *lucetia* from the Imatong Mountains are of the typical form. Four males and three females of an interesting new geographical race of this species were taken in Didinga. It combines the appearances of a typical *lucetia*, Hew., and of *denuba*, Plotz, the latter being a Western species. It has been sent by Hodson from S.W. Abyssinia, and a single specimen (paratype) in the British Museum was taken by Major C. W. Gwynn at Kaffa in S.W. Abyssinia in 1909.

Fore-wing.—The hyaline spots are in plan as in *lucetia*, but the chief spot in area 2 is in the male, as in *denuba*, almost square instead of being elongated transversely as in *lucetia*, while even in the female it is not so elongated as in typical *lucetia*. The part of the wing immediately behind this large spot, which in *lucetia* is white (internal to the two spots in area 1*b*), is of the same yellowish grey as the rest of the fore-wing, which, on the whole, is more yellowish than the brownish grey of *lucetia*. It is this lessening of the white area which makes this new race so different in appearance from the typical form.

Hind-wing.—The pale area is somewhat more yellowish than in *lucetia*, especially in the male. The row of dark spots internal to the dark border at the anterior angle of the hind-wing is less conspicuous than in *lucetia*, but in the female it is continued faintly across the yellowish white area to the inner margin. Parallel with this row of spots, between it and the margin in the female, is a transverse dark line continued from the posterior end of the dark apical area to the anal angle.

Type.—A male from Didinga, taken 1.i.1926 (Pl. II, fig. 5). Paratypes in Hope Collection, Tring, and British Museum, the last a male from Abyssinia.

170. **Sarangesa (Eretis) lugens,** Rghfr. I +, N —.

Both the other collections have a long series of the closely allied *laelius*, Mab., which we did not find in Didinga.

171. **Sarangesa subalbicans,** B.-B. I —, N —.

172. **Celaenorrhinus intermixtus,** Auriv. I +, N —.

173. **Celaenorrhinus bettoni,** Btlr. I +, N —.

Summary, and Concluding Remarks.

I.—The number of species collected in Didinga reaches a total of 117. From the Imatong Mountains, about 50 miles to the west, Kent-Lemon sent 56 additional species which were not taken in Didinga. The groups to which the species belong, in these two localities, are shown below :—

	Didinga.	Imatong; not Didinga.
Papilioninae	5	4
Pierinae	26	11
Danainae	5	1
Satyrinae	4	15
Nymphalinae	35	17
Acraeinae	9	8
Erycinidae	1	
Lycaenidae	16	?
Hesperiidae	16	?
	117	56
Total from two localities	173	

The Lycaenidae and Hesperiidae from the Imatong Mountains could not be listed, as there was insufficient time at my disposal to identify them all.

II.—Five species showed sufficient variation from known forms to be described as new geographical races or subspecies. These are as follows :—

Serial No.

1. *Papilio rex*, subsp. nov. *franciscae*.
3. *Papilio nobilis*, subsp. nov. *didingensis*.
13. *Mylothris rüppelli*, subsp. nov. *septentrionalis*.
52. *Amauris lobengula*, subsp. nov. *mongallensis*.
162. *Eagris lucetia*, subsp. nov. *obliterata*.

III.—Study of the geographical races of many wide-ranging species was of considerable interest, which is increased by the fact that the forms on the Imatong Mountains are not always the same as on the Didinga range (*e.g.* Nos. 5 and 100). In some cases the Didinga specimens show a considerable degree of approach to those sent by Mr. Arnold Hodson from S.W. Abyssinia (see table). It would have been very interesting to have been able to describe the Hodson collection and discuss the geographical affinities of the S.W. Abyssinian butterflies, but time did not permit more than the attempt to decide whether species taken in Didinga had also been found in S.W. Abyssinia, and, if so, whether they were alike.

Table showing the geographical forms of some of the species in Didinga and the Imatong Mountains.

Western (including Uganda).	Transitional to W.	Eastern.	Transitional to Abyssinian.
2. *Pap. dardanus*, ♀ *f. planemoides.*	50. *Amauris niavius.*	4. *Pap. phorcas ansorgei.*	1. *Pap. rex franciscae.*
33. *Teracolus elgonenis glauningi.*	89. *Pseudacraea boisduvali.*	21. *Belenois zochalia.*	49. *Tirumala formosa.*
74. *Charaxes c. castor.*	106. *Catacroptera cloanthe ligata.*	75. *Charaxes hansali baringana.*	50. *Amauris niavius.*
76. *Charaxes p. pollux.*	108. *Precis terea.*	78. *Charaxes smaragdalis orientalis.*	73. *Charaxes b. brutus.*
100 (in part). *Eurytela h. hiarbas.*	113. *Precis octavia.*	99. *Neptidopsis ophione velleda.*	139 (in part). *Acraea zetes.*
	132. *Acraea caecilia.*	100 (in part). *Eurytela hiarbas lita.*	
	139 (in part). *Acraea zetes.*	101. *Eurytela dryope angulata.*	
	169. *Eagris lucetia obliterata* (this race not in Imatong Mtns.).	105. *Salamis parhasus aethiops.*	
		124. *Planema poggei nelsoni.*	
		139 (in part). *Acraea zetes.*	

There are thirteen species either of Western form or transitional towards or from the Western form. Two species however (100, *Eurytela hiarbas*, and 139, *Acraea zetes*) also have Eastern forms. In one case (50, *Amauris niavius*) the species is transitional towards the Abyssinian form and at the same time is, on the whole, of Western rather than Eastern appearance. This is because the Abyssinian form is apparently derived from the Western race. It is remarkable how many of the Abyssinian species are of Western type, and it can only be concluded that the forest links between Abyssinia and West Africa were formerly closer than at the present time. The isolated mountains with forested summits shown on the map appended to this paper (p. 27) could hardly serve as stepping-stones at the present day, but should more probably be regarded as sanctuaries into which species have been driven, as the plains around the mountains gradually became drier and the forest died out.

It is most interesting to find that, in some respects, the Nuba Mountains seem to have an even greater Western affinity than the Didinga or Imatong country (see remarks about *Telipna* at the end of the section on LYCAENIDAE, and also the remarks upon Nos. 113, *Precis octavia*, and 132, *Acraea caecilia*). Possibly this affinity is to be simply explained by the fact that the Nuba Mountains are more out of touch with the Eastern fauna than the other localities. In one case the Eastern form exclusively occurs in Didinga, while the single specimen from the Imatong Mountains is of the Western form (No. 100, *Eurytela hiarbas*). In this case the Abyssinian specimens were also Eastern in appearance. In the case of No. 5, *Pap. nireus*, the Didinga race (*lyaeus*) is distinct from that near Imatong and in S.W. Abyssinia (*pseudonireus*), as also from the Nuban race (*wilsoni*). There is, however, a considerable upper surface resemblance between the specimens from Didinga and Abyssinia, and between the Imatong and the Nuban. No. 139, *Acraea zetes*, appears in a variety of forms, either

intermediate between Eastern and Western or transitional to the very remarkable form assumed in Abyssinia, where also forms occur like those from Uganda, although it has not been ascertained as yet whether the localities in Abyssinia are exactly the same for these different forms.

Ten species are of decidedly Eastern form, although two of them (Nos. 100, *Eurytela hiarbas*, and 139, *Acraea zetes*), also include forms of a more Western character. The chief interest, however, is in the five species which are transitional to the peculiar forms appearing in Abyssinia. This paper shows once again how transitional forms *are* found just where the map would lead one to expect to find them.

IV.—*Seasonal forms.*—Certain species well known to exhibit seasonal dimorphism were taken in Didinga. The following meteorological data are therefore of interest, and may be considered before the butterflies are discussed. These data were first taken in April 1922, and have been continued ever since by Mr. J. H. Driberg (the district officer) and Major Wynne-Finch of the Sudan Defence Force, to whom I am indebted for the following figures.

For the months of January, February and March the records for 1923, '24, '25 are given; for April and following months records were obtained from 1922 onwards.

The maximum temperature ever recorded was 82·9 F.

The minimum temperature ever recorded was 49·6 F.

The maximum rainfall ever recorded in 24 hours was 1·98 inches, while the average yearly rainfall over three or four years was 41·86 inches.

The following table gives the figures for each month, and the average for three or four yearly records.

The monthly figure represents the average of the daily maxima and minima of temperature.

	Maximum temperature.	Minimum temperature.	Rainfall in inches.
January 1923	75·9	61·4	0
„ 1924	75·7	60·0	0
„ 1925	74·2	56·4	0·23
Average	75·3	59·3	0·07
February 1923	73·1	59·7	1·84
„ 1924	74·2	59·6	1·91
„ 1925	76·7	58·1	0·72
Average	74·7	59·1	1·49
March 1923	74·4	60·6	2·21
„ 1924	78·6	62·2	1·74
„ 1925	76·2	59·3	3·59
Average	76·4	60·7	2·51
April 1922	72·6	60·6	4·42
„ 1923	69·7	58·7	6·61
„ 1924	71·5	59·3	5·89
„ 1925	76·7	60·4	0·71
Average	72·6	59·7	4·41

	Maximum temperature.	Minimum temperature.	Rainfall in inches.
May 1922	68·9	58·9	5·48
„ 1923	67·7	57·7	8·91
„ 1924	72·3	57·8	2·35
„ 1925	71·7	58·2	5·84
Average	70·1	58·1	5·64
June 1922	69·0	58·3	8·86
„ 1923	67·5	57·0	8·57
„ 1924	73·9	55·3	0·54
„ 1925	68·9	56·8	5·37
Average	69·8	56·8	5·83
July 1922	67·1	57·0	8·00
„ 1923	64·7	55·5	12·74
„ 1924	68·4	56·4	8·41
„ 1925	67·7	56·5	7·41
Average	66·9	56·3	9·14
August 1922	65·6	56·7	8·63
„ 1923	67·6	55·5	4·17
„ 1924	66·8	56·1	11·83
„ 1925	68·1	55·6	4·04
Average	67·0	55·9	7·17
September 1922	65·9	56·6	3·44
„ 1923	69·6	56·3	0·98
„ 1924	70·5	56·0	4·95
„ 1925	74·6	55·8	0·22
Average	70·1	56·2	2·39
October 1922	70·6	58·5	0·92
„ 1923	69·7	57·5	2·80
„ 1924	73·5	57·4	1·47
„ 1925	75·5	57·0	1·08
Average	72·3	57·6	1·57
November 1922	74·9	59·3	0·08
„ 1923	70·7	57·3	1·84
„ 1924	72·7	57·8	1·44
„ 1925	75·5	57·0	1·08
Average	73·4	57·8	1·11
December 1922	74·0	58·3	0·15
„ 1923	72·2	58·2	0·86
„ 1924	73·9	58·2	1·05
„ 1925	74·6	57·8	0·09
Average	73·7	58·1	0·53

In regard to seasonal forms the species of *Precis* are of chief interest. The PIERINAE which show dimorphism were not taken in sufficient numbers to enable a definite statement to be made as to whether or not they agree with the seasons, but the few specimens of the three species of *Terias* (43, 44, 45) were all on the " wet " rather than on the " dry " side. The total rainfall for the year was well under the average, having been only 30·38 inches, *i.e.* about 25 per cent. below normal, while the collections were made in the height of the dry season. The two chief species of *Precis* at Didinga did not quite agree (Nos. 110, *archesia*, and 113, *octavia*).

P. archesia is represented by 48 specimens, of which 46 make an extremely uniform series of a form coming just on the wet side of *semitypica*, which is about mid-way between extreme wet and dry forms. In fact, the Didinga specimens lean as much towards the wet side of the mean as the form *staudingeri* does toward the dry side. Considering the dryness of the year as a whole it might have been expected that the specimens would have been even " drier," as they were captured in the height of the dry season. A single specimen of *archesia* is of the full " wet " form *pelasgis*, and is old and worn : another comes very near to it.

P. octavia differs considerably in being far more on the " dry " side. Out of 113 specimens 61 were of the full dry form *sesamus*, 27 very slightly transitional towards the " wet " form *natalensis*, 12, while still " dry," showed a stronger transition to the " wet " form, while only 13 were of the " wet " form. The fact that *octavia* is on the whole of a far " drier " form than *archesia* is of interest, seeing that both were taken at the same time and place.

Nos. 53 and 54, two species of *Melanitis*, were of the " wet " rather than the " dry " form.

Finally, it may be said that a small collection of Mollusca was made in Didinga and presented to the British Museum. Major M. Connolly has identified them and communicated to the Malacological Society a short paper describing two new species. More recently he has been hard at work on Dr. Hugh Scott's Abyssinian Mollusca, and informs me that none of the land-shells from Didinga were present in the collection, in which they differ sharply from the butterflies.

EXPLANATION OF PLATES.

PLATE I.

The forest and grass-land on the flat summit of the Didinga Range.

PLATE II.

All specimens from Didinga, and all of the natural size.

FIG. 1. *Papilio rex franciscae*, subsp. nov., ♂. 16.xii.1925. A specimen showing the sickle-shaped spot on fore-wing entirely suffused with red-brown, and great development of the mealy spot. The type specimen.

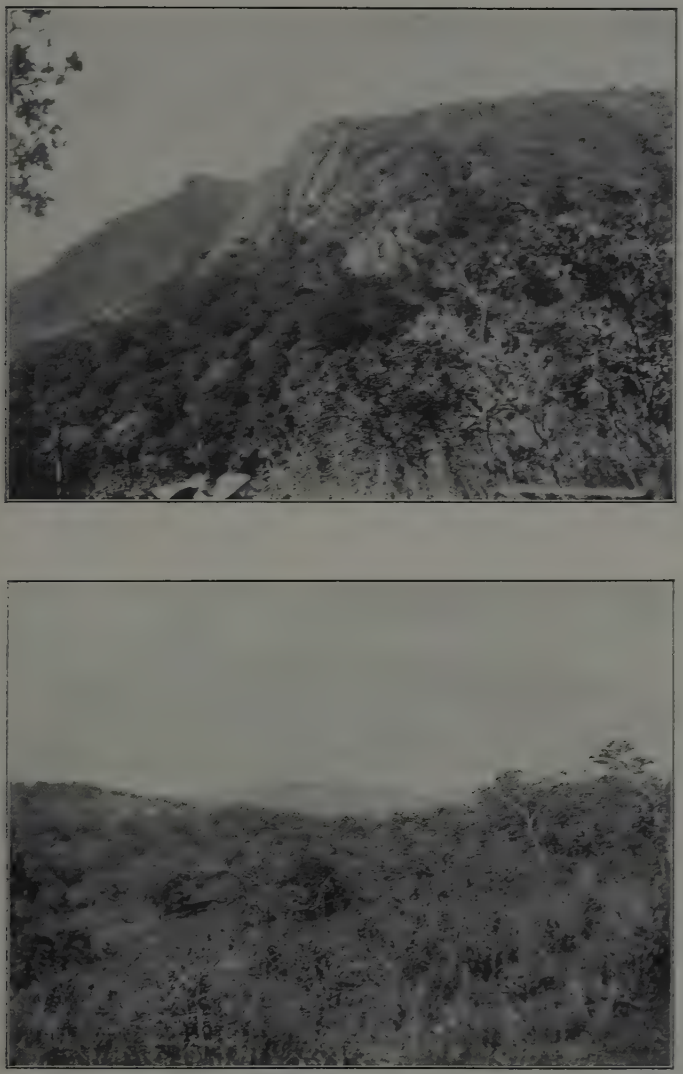
2. *Papilio rex franciscae*, ♀. 30.xi.1925. Shows the maximum development of red-brown.

Fig. 3. *Mylothris rüppelli septentrionalis*, subsp. nov., ♂. 5.i.26.
4. „ „ „ „ ♀. „ . The type specimen.
5. *Eagris lucetia obliterata*, subsp. nov., ♂. 1.i.26. The type specimen.
6. „ „ „ „ ♀. 27.xii.25.

Plate III.

All specimens from Didinga, and all of the natural size.

Fig. 1. *Papilio nobilis didingensis*, subsp. nov., ♂. 25.xii.25.
2. „ „ „ „ ♀. „ The type specimen.
3. *Teracolus elgonensis glauningi*, A. Schultze, ♂. 6.i.26.
4. „ „ „ „ „ ♀. „
5. *Amauris lobengula mongallensis*, subsp. nov., ♂. 26.xii.25. The type specimen.



G. D. H. Carpenter, photo. *Vaus & Crampton, Ltd.*

THE DIDINGA MOUNTAINS.—TWO TYPICAL VIEWS.

A. Robinson, photo.

BUTTERFLIES OF THE DIDINGA MOUNTAINS.

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A. Robinson, photo.

BUTTERFLIES OF THE DIDINGA MOUNTAINS.

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A PERMIAN FOSSIL DAMSELFLY WING FROM THE FALKLAND ISLANDS

By R. J. Tillyard, M.A., Sc.D. (Cantab.), D.Sc. (Sydney), F.R.S., F.L.S., F.G.S., F.N.Z.Inst., C.M.Z.S.

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[Read March 21st, 1928.]

Plate IV and Three Text-figures.

In August, 1926, while I was on a visit to England, my friend Professor Sir T. W. E. David, F.R.S., drew my attention to the fact that a fossil insect wing had been discovered by T. G. Halle in the rocks of the Gondwanan series at Bodie Creek Head, Falkland Islands, in 1908. This discovery had been briefly recorded by G. Holm, with a figure, in the section headed " Insect Remains " of Halle's paper (1911), but the specimen had not been named, nor had it been described beyond a few general remarks in which the author placed it in the extinct Order Palaeodictyoptera and offered a few considerations about that Order.

The sketch copy of the figure which Professor David kindly sent me showed an undoubtedly petiolate wing with an outline similar to that of a damselfly. I therefore set about obtaining more information on this interesting fossil. Through the kindness of my friend Hr. Esben Petersen of Silkeborg, Denmark, I was at last enabled to get into touch with Professor Erik Stensio, in charge of the Palaeontological Department of the Natural History Museum at Stockholm, where the fossil is now deposited. He very kindly sent me a quarter-plate negative and two good prints of the wing, enlarged. From these it was easy to see that we had to deal with a true damselfly wing of primitive type. But many important details could not be made out from this photograph. I therefore begged Professor Stensio to lend me the specimen for a few days while I was still in London, and this he most obligingly did. I received the specimen on a Saturday morning; with the aid of a " Baby London " microscope, with camera lucida attachment, I was able to study this difficult fossil in full detail in my hotel, making the necessary drawings, and returning it to its owner with the least possible delay. I wish here to express my most grateful thanks to Professor Stensio for his action in lending me this unique specimen, and in providing the photograph of it, of which a reproduction, improved by Mr. W. C. Davies, Curator of the Cawthron Institute, is shown in Plate IV.

The chief interest of the specimen is that it is undoubtedly the oldest known type that can be definitely placed within the Suborder Zygoptera of the Order Odonata. The term Permo-Carboniferous, applied somewhat loosely to the Gondwana series of beds, was coined by Mr. R. Etheridge, Junr., of the Australian Museum, Sydney, many years ago, and was based upon an analysis of the marine fauna of the beds. The fresh-water fauna, however, of the corresponding series in New South Wales has yielded abundant insect remains, which have been fully studied by me elsewhere (1918–26), and which lead one to the inevitable conclusion that these beds are high up in the Upper Permian. This conclusion has lately been confirmed by geological evidence; for a shaft has now been sunk

almost on the very spot where the first insect wings were found by Mr. John Mitchell of Newcastle, N.S.W., and he himself was the first to descend this new shaft and study the succession of strata so exposed to view. The result proves that the so-called "Permo-Carboniferous" strata merge without any break into the Lower Trias, which lies only about 300 feet vertically above them, the division being taken at the line of strata where the *Glossopteris*-flora disappears. One may reasonably assume that beds from which the present fossil wing came are also of Upper Permian age, for the wing is of a far more advanced type than that of *Kennedya* from the Lower Permian of Kansas (Tillyard, 1925*a*).

The outstanding features of the wing of *Kennedya* were the primitive nodus, the presence of a basal remnant of the first cubital vein within the basilar space in the petiole, and the complete absence of any sign of specialisation in the area where the discoidal cell of Odonata is formed later on. For these reasons, this genus could not be placed within the Suborder Zygoptera, which it otherwise resembles, but required the formation of a new Suborder Protozygoptera for its reception.

In the theory of the evolution of the Odonata which I have set out briefly in my "Insects of Australia and New Zealand" (Tillyard, 1926*c*), *Kennedya* is taken as the starting point of the Order, and it is assumed that true Zygoptera arose through the loss of the remnant of Cu_1 basally and specialisation in the region of the discoidal cell. No true Zygopteron as simple as this was known; for even the oldest of the recorded fossils (*Triassolestes* and *Triassagrion* of the Upper Triassic of Ipswich, Queensland) were considerably more advanced than this.

Now comes the discovery of this Upper Permian form, and it is very satisfactory to find that it fits exactly the theory of the evolution of Zygopterous types outlined in my book, provided that its age be Upper or Middle Permian. That is to say, it is an advance on *Kennedya* by the loss of Cu_1 and by marked, though comparatively slight, specialisations in the region of the nodus and discoidal cell, while at the same time it stands far behind *Triassolestes* or *Triassagrion*.

It will be best to give a description of the specimen and its venation before discussing its relationship with other known forms.

Order ODONATA.

Suborder *ZYGOPTERA*.

Family **PERMAGRIIDAE**, fam. nov.

Zygoptera having petiolate wings with only two antenodals; nodus of primitive form with subnodus in process of formation by oblique alignment of two cross-veins situated basad from it between Sc, R_1 and Rs; discoidal cell (*q*) still open basally, but with the discoidal cross-vein forming a strong, oblique, distal side between MA and Cu_2; subdiscoidal cell (*sq*) complete.

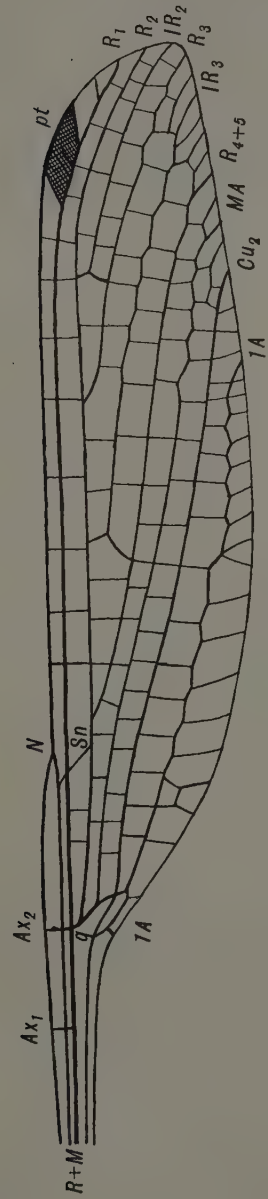
Genus **PERMAGRION**, n.g.

(Text-figs. 1–3; plate IV.)

* Nodus at about one-third of the wing-length from base. Petiole well-formed, about one-sixth of the total length of the wing. Sectors of the arculus (Rs and MA) arising well

* Explanation of Venational Notation in Text-figures.

The venational notation given in the Text-figures is the New Notation as set out in *Insects of Australia and New Zealand* (Angus and Robertson, 89, Castlereagh St., Sydney, publishers, 1926), in the Comparative Table on p. 68 of that work. Students who are accustomed to use the Needham Notation should consult that table and also the papers quoted under Tillyard, 1925*a*, *c*, in the References at the end of this paper.—R. J. T.



TEXT-FIG. 1.—*Permagrion falklandicum*, n.g. et sp. Complete wing, length 34 mm., with apex turned to right to facilitate comparison with other Odonate wings.

apart, Rs from high up, close to R_1, MA low down, at level of Cu_2 before it bends down along the discoidal cell. Subquadrangle (*sq*) complete, formed by the separation of 1A from Cu_2 basally and closed distally by a specialised cross-vein (the subdiscoidal cross-vein *sdc*), somewhat obliquely placed, continuing the discoidal cross-vein (*dc*) downwards to 1A, which is slightly bent just basad from this point, between it and a short cross-vein on to the posterior margin; a second cross-vein supports it more basally between 1A and posterior margin. Subnodus (*Sn*) placed distinctly basad from nodus and not yet forming part of the nodal complex; it consists simply of two oblique cross-veins in line, passing from Sc across R_1 to Rs. The costa is somewhat arched basad from nodus, so that the line of Sc is continued distad, beyond nodus, by the costa itself. All the descending branches of Rs arise distad from the subnodus: R_{4+5} only slightly distad, IR_3 about half-way along the wing, R_3 about half-way between nodus and apex of wing, and IR_2 two cells distad from it. The simple descending origins of the true branches of Rs, viz. the concave veins R_3 and R_{4+5}, are in marked contrast to the Y-vein connections of the interpolated middle members of the triads, IR_2 and IR_3. All these branches are subparallel to one another, but IR_3 and MA tend to become slightly zigzagged distally, while 1A begins to become zigzagged four cells length from the subdiscoidal cell, and its distal portion, from the line of cross-veins descending from origin of IR_3 right to its apex, is very irregular and converges somewhat towards Cu_2 above it. Cu_2 arches slightly upwards after leaving discoidal cell.

Pterostigma trapezoidal, placed far distad towards apex, with only two cells beyond it between costa and R_1; covering one small complete cell and portions of two others. Cross-veins moderately numerous, all in single rows between the main veins, with the single exception of one divided cell in the postcostal space. No true supplementary sectors present, but the branched endings of IR_3, R_{4+5} and MA indicate how these begin in the course of evolution. Postnodals apparently eight in number, rather irregularly placed. Practically no transverse alignments of cross-veins.

Apex of wing distinctly nodding, the actual apex being situated at the end of IR_2, and hence the costal margin very strongly curved from pterostigma to apex.

Genotype: Permagrion falklandicum, n.sp.
Horizon: Bodie Creek Beds, Gondwana (Upper Permian), Falkland Islands.

Permagrion falklandicum, n. sp.

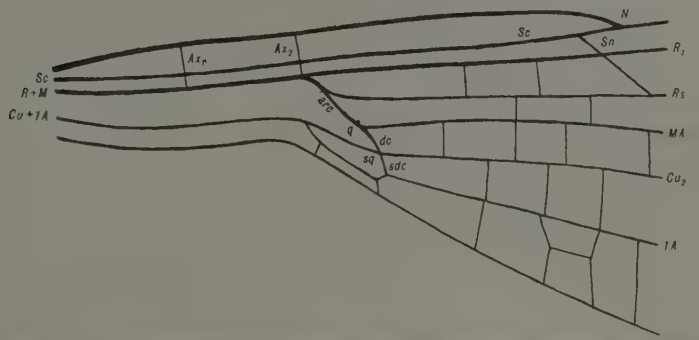
(Text-figs. 1–3; plate IV.)

Length of wing (complete) 34 mm.; *greatest breadth* 6 mm.: *petiole* slightly over 6 mm.: *nodus* about 12 mm. from base.

The specimen lies on an irregular, somewhat adze-shaped piece of hard, cherty rock, about 4 inches long by 3 inches wide and 1 inch deep. The portion on which the wing is impressed is dark russet-brown, overlaid with carbonised remains of plants, which partially encroach upon the wing from the edge of the rock. The wing itself is complete and fairly well preserved. There are two raised ruckings of the rock surface which cross it transversely, one near the middle and one in the region of the pterostigma; these appear to be due to plant remains, probably slender stalks, and cause a slight distortion of the veins where they pass them; they branch somewhat, as may be seen from the photograph in plate IV. Cross-veins are mostly visible, but not very distinct. Main veins quite clear except for the basal portions of R + M and Cu_2 + 1A in the petiole. It is quite impossible to state definitely whether there was any remnant of Cu_1 present in the petiole, or whether a distinct Ac was present below Cu_2 + 1A: the most careful examination of the wing which I could make showed no sign of either, and I conclude that it is highly probable that both were absent. Ax_1 is apparently situated half-way along the petiole, Ax_2 exactly above the arculus, but neither of them is very clear. Most of the postnodals are also only faintly

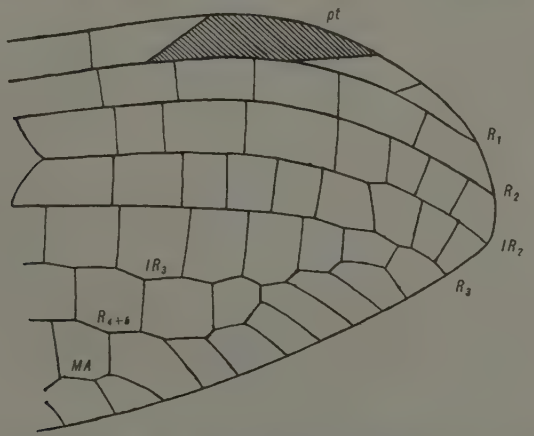
marked, and I cannot be quite sure whether there are actually eight, or only seven; the most distal one looks at first like the basal side of the pterostigma, but more careful examination seems to indicate that the true basal side is more oblique and more distally placed.

A curious point about the wing is that R lies very close to Sc basally from the nodus, the



TEXT-FIG. 2.—*Permagrion falklandicum*, n.g. et sp. Basal part of wing to nodus, enlarged (× 10) to show structure of petiole, arculus (*arc*), nodus (*N*), subnodus (*Sn*), discoidal cell (*q*) and subdiscoidal cell (*sq*).

space between C and Sc being twice as wide as the space between Sc and R. Sc is nearly straight to the nodus, but C curves downwards considerably to the nodus, so that the distal end of the costal space is narrowly lanceolate in shape. Beyond the nodus, C is almost in line with Sc before it, and the width of the space between C and R_1 is markedly less than that



TEXT-FIG. 3.—*Permagrion falklandicum*, n.g. et sp. Apical part of wing, enlarged (× 10), to show pterostigma (*pt*) and nodding apex.

between R_1 and Rs. The widest space in the wing is the postcostal (between 1A and posterior margin), while the space above this, between Cu_2 and 1A, is the next widest. Cross-veins are rather irregularly placed, with nothing but chance alignments of two or more transversely across the wing; as far as can be made out, there are 162 closed cells in the whole wing.

It is interesting to note that quite a number of the cross-veins appear to be pale straw-coloured on a darker membrane. This would indicate that the wing was strongly pigmented, either wholly or in part, but the boundaries of this pigment cannot be accurately traced.

The wing is a left wing, and most probably a hind-wing. It lies on the rock with apex to the left, as shown in plate IV. But, in order to facilitate comparison with the venation of other Zygopterous types, the figures of it have been reversed and the apex has been placed to the right, as in all other drawings of fossil insect wings in my more recent papers.

Type: Holotype wing in the Palaeontological Collection of the Natural History Museum, Stockholm. *Label on Specimen:* (Printed) "Riksm. Pal. zool. Avd/Stockholm/Falklandsöarna"; (written) "Bodie Creek Head/N : r Ar. 2168." On large loose labels sent with the specimen are the following :—

(Printed) "Naturhistoriska Riksmuseum, Stockholm";

(Written) "Insektvinge / Falkland Islands / Bodie Creek Head"; and

(Written) "Insektvinge / Falklandsöarna / Gondwana-formation / T. Halle 1908 / Inkönt."

Locality: Rocks of Gondwanan age at Bodie Creek Head, Falkland Islands.

Comparison with Known Forms.

When we come to consider this fossil carefully, the genera with which it most obviously invites comparison are those in which the discoidal cell remains open. Of these, the most archaic by far is the Lower Permian *Kennedya* from Kansas (Tillyard, 1925*a*, p. 63, figs. 10–12), the most primitive complete wing yet discovered within the Order Odonata. We at once notice a number of remarkable resemblances between the two genera, as follows :—

(1) The extremely simple and primitive nodus, placed close to the base of the wing (about twice the length of the petiole from base in *Permagrion*, a little less in *Kennedya*), and formed by the meeting of the markedly curving costa with the simple and only slightly upcurving end of the subcosta.

(2) The narrowness of the space between Sc and R before nodus, and of the space between C and R beyond the nodus.

(3) The absence of any true subnodus (*Sn*) in both. But here we have also to note that *Permagrion* is in advance of *Kennedya* in that, while the latter shows absolutely no sign whatever of the beginnings of a subnodus, the former has two cross-veins (*Sn*) somewhat basad from N already obliquely placed and aligned, indicating clearly how the true subnodus of recent Odonata has been formed.

(4) The marked contrast between the simple descending origins of the true branches of Rs, viz. R_3 and R_{4+5}, and the Y-vein origins of the two interpolated middle triadic members, IR_2 and IR_3.

(5) The fact that all branches of Rs arise distad from the nodus. Here, again, we must note that *Kennedya* has R_{4+5} arising far distad from the nodus, whereas in *Permagrion* this vein arises only slightly distad from the lower end of *Sn*. The great majority of existing genera of Zygoptera have both R_{4+5} and IR_3 arising either at or a little before *Sn*, though in *Prionocnemis* we can still find a condition very close to that shown in *Permagrion*.

(6) The tendency of Cu_2 to arch upwards after leaving the cross-vein *sdc*. This we must regard as a very primitive character, since it is to be noted in an even more strongly marked condition in most of the Protodonata. In recent forms, it is only retained in the family Synlestidae.

(7) The incomplete discoidal cell is supported below by a *complete* subdiscoidal cell.

We may now note the following differences, in all of which *Permagrion* shows distinct advance in specialisation over *Kennedya* :—

(1) An increase in the number of cross-veins of the wing. *Kennedya* has only four equally-spaced postnodals, and the total number of closed cells in the wing is just over a hundred. *Permagrion* has eight postnodals, unevenly spaced, and the total number of closed cells is 162.

(2) The arculus in *Permagrion* comes off at a greater angle from R than in the case of *Kennedya*.

(3) The discoidal cell, though open in both genera, is more primitive in *Kennedya*, in so far as the distal cross-vein *dc* is entirely unspecialised in that genus, being a short cross-vein at right angles to its two main veins, and not nearly aligned with the more specialised cross-vein *sdc* which closes the subdiscoidal cell below. In *Permagrion*, not only is *dc* strongly chitinised and distinctly oblique, but it is also aligned with *sdc* below it, as in all recent Zygoptera. The condition seen in *Permagrion* is not very far behind that in the recent Australian genus *Chorismagrion*.

(4) The cross-veins below the subdiscoidal cell are more advantageously placed in *Permagrion* than in *Kennedya*, and indicate a close approach to the condition shown in the recent Australian genus *Hemiphlebia*.

(5) The pterostigma is more specialised in *Permagrion* and the apex of the wing assumes the definitely nodding form found in recent Synlestidae.

(6) Zigzagging of distal portions of alternate main veins has only just begun in *Kennedya*, the only vein thus affected being IR_3. In *Permagrion*, not only is IR_3 zigzagged distally, but so also are MA and 1A.

If we add to these the two points mentioned beforehand in dealing with the similarities between the two genera, viz. the beginnings of the formation of a subnodus in *Permagrion* and also the precession of R_{4+5} basad towards *Sn*, we can now state definitely that *Kennedya* is the more primitive type of the two, and that *Permagrion* has been evolved from some form within the Lower Permian family Kennedyidae (probably a form with slightly wider wings than *Kennedya* itself). Bearing in mind that *Permagrion* is far more primitive than any other known Zygopterous types (except *Kennedya*), we are justified in placing it at about Upper Permian age, and this agrees closely with what we have discovered concerning the so-called " Permo-Carboniferous " in Australia.

Before we begin to compare *Permagrion* with recent forms, we must emphasise the great importance which we can now see is attached to the evolution of the *subdiscoidal cell* or *subquadrangle* (*sq*). In my work on the Liassic Dragonflies, I was greatly struck by this very point (Tillyard, 1925*b*, especially text-figs. 2, 3, 8, 9); but the key to the evolution of this cell was at that time missing. It is, however, clear that the basal side of this cell is always the true *anal crossing* (*Ac*), and hence we must now slightly revise our notation for *Kennedya*. The very faint cross-vein which supports the end of Cu_1 from below, in the petiole of that genus, is not *Ac*, but an older development which, we may presume, disappeared when Cu_1 disappeared; *the true* Ac *was originally the basal portion of* 1A, *where it diverges from* Cu_2 *after its fusion with that vein in the petiole.* This is proved conclusively, not only by the fossils as we now know them, but also by the larval tracheation, which always shows trachea 1A leaving trachea Cu_2 at *Ac*. Hence we now have to reach a further conclusion of the utmost importance :—

The original course of trachea 1*A was along vein* 1*A, leaving* Cu_2 *by way of*

Ac; *but a secondary trachea from* Cu_2 *along the course of the specialised subdiscoidal cross-vein* sdc *has captured the whole of the distal course of* 1*A*, *leaving trachea* Ac *stranded; from this stranded trachea a secondary supply to the new vein called the secondary anal* (A′) *has been developed in all higher types of Odonata.*

This discovery throws a flood of light upon the evolution of the whole of the Zygoptera as well as the Anisoptera. For we now see that the genus *Hemiphlebia* is primitive in almost every respect, inclusive of the retention of the original condition of the subquadrangle, whereas, previously (Tillyard, 1926*c*, p. 76) we had considered it specialised in this area.

We may now indicate some existing genera which, on the evidence of the fossils, retain the most primitive condition of the veins in certain important points :—

(1) *All the branches of* Rs *remaining distally placed from nodus and nearly equally spaced: Prionocnemis.* Very primitive forms slightly more specialised than this by approach of IR_3 basally close up to R_{4+5}: *Selysioneura, Oristicta, Isosticta, Protosticta.*

(2) *Retention of the complete subquadrangle* (sq), *with its two supporting cross-veins beneath: Hemiphlebia;* all the less reduced forms within the Coenagrioidea: *Diphlebia.* We can now see clearly that the secondary anal vein A′ began to be formed when the original free basal portion of 1A took on the form of a cross-vein *Ac*, while the supporting cross-vein below it became oblique in position and subsequently aligned itself with the postcostal vein of the petiole; this is beautifully exhibited in the genus *Diphlebia*, while *Rhinocypha* shows a type in which *Ac* still retains an oblique position, though A′ is becoming already well developed.

(3) *Upward arching of the vein* Cu_2 *after leaving cross-vein* sdc *:* Only retained in the family Synlestidae.

(4) *Quadrangle remaining open basally: Hemiphlebia, Chorismagrion.*

(5) *Nodus close to base of wing* (one-third of wing-length from base, or less): most Coenagrioidea, and all the family Pseudostigmatidae in particular, where the distance is usually only about one-seventh of the wing-length. The genus *Thaumatoneura* of the Megapodagriidae also has this character most strongly marked.

With the discovery of *Permagrion*, the last essential for the construction of a complete phylogeny of the wing-venation of the Order Odonata has been provided; there are now no more gaps of outstanding importance to be filled. When we come to construct this phylogeny, we shall find that the other characters, larval and imaginal, fit in remarkably well with the evidence from the wing-venation, so that it is possible to reconstruct in almost every detail the story of the evolution of the Order from the Lower Permian to the present day. This task I must leave to be done in a series of later papers.

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WING OF *PERMAGRION FALKLANDICUM* n. gen. et sp.

Tillyard, R. J., 1926*a*. "Kansas Permian Insects. Part 6. Additions to the Orders Protohymenoptera and Odonata." Amer. Journ. Sci., vol. xi, Jan. 1926 (pp. 69–73).

——, 1926*b*. "Kansas Permian Insects. Part 7. The Order Mecoptera." *L.c.*, vol. xi, Feb. 1926 (alterations to venational notation in Odonata on p. 136).

——, 1926*c*. "Insects of Australia and New Zealand." Publ. by Messrs. Angus and Robertson, Ltd., 89, Castlereagh Street, Sydney, N.S.W. (Chap. IX, pp. 65–86, Order Odonata; see in particular figs. F3, F4, etc., and note that notation of branches of Rs in fig. F4 should be altered to conform with the other figures; viz., R_{2a}, IR_{2a}, R_{2b}, IR_{2b}, R_3 should become R_2, IR_2, R_3, IR_3 and R_{4+5} respectively.)

Explanation of Plate IV.

Wing of *Permagrion falklandicum*, n.g. et sp. (length 34 mm.) *in situ* on rock of Gondwanan (Upper Permian) age from Bodie Creek Head, Falkland Islands (Natural History Museum, Stockholm.)

SOME REMARKS ON THE DEVONIAN FOSSIL INSECTS FROM THE RHYNIE CHERT BEDS, OLD RED SANDSTONE

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(Assistant Director and Chief of the Biological Department, Cawthron Institute, Nelson, N.Z.)

[Read March 21st, 1928.]

With Three Text-figures.

The Arthropod remains * found in small flakes of Rhynie Chert from the Old Red Sandstone of Scotland have been dealt with in two papers. The first of these, by Mr. Stanley Hirst (1923), deals exclusively with Arachnids and includes the first true Acari discovered in Palaeozoic strata. The second paper, by Hirst and Maulik (1926), deals with a doubtful Merostome and some presumed insect remains. One of the supposed insects is represented by four more or less imperfect heads, each preserved in a small flake of Rhynie Chert, and has been named *Rhyniella praecursor*, Hirst and Maulik. The other supposed insect has not been named, as it is only represented by a pair of jaw-like structures, suggesting the mandibles of an insect, with remnants of other structures around them.

Both the description and the figures of *Rhyniella praecursor* raised considerable doubt in the minds of entomologists, as to whether this fossil really represented an insect head or not, and, if an insect, as to what Order it might belong to. I therefore asked Mr. Hirst to show me his preparations, and I wish to thank him for the very kind and ready manner in which he acceded to my request.

My first examination of the specimens fully bore out the difficulty of coming to a definite conclusion on the basis of such material. There are four specimens of *Rhyniella praecursor*, each contained in a tiny flake of Rhynie Chert mounted on a slide in Canada Balsam, and containing also a considerable amount of vegetable material. These fine flakes are semitransparent when so mounted, and can be examined by transmitted light. One gets the impression readily enough that it might be the original chitin of the head capsule that is still imprisoned in the flake of rock, but at the same time very much worn down and attenuated before fossilisation was achieved, probably by the action of the water in the bog or swamp in which these little Arthropods apparently lived and died. More probably, however, the original substance was replaced by silica after becoming worn down by such action.

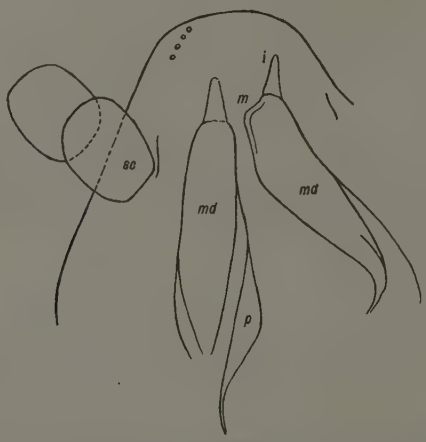
There is an inconsistency in the description which tends to add to one's confused state of mind when examining these fossils. Hirst and Maulik (1926, p. 71) describe the four-segmented appendage, visible on the right side of the best-preserved head-capsule (Plate VII, fig. F, of their paper), as a palp; but, in the succeeding paragraph, in giving the measurements, they call it an antenna. I asked Mr. Hirst which he really thought it was, and he replied that he did not know. And it must be admitted that the interpretation of

* Exclusive of Crustacea.

these minute and imperfect remains is full of difficulty even to an entomologist with a wide experience in fossil insects.

In studying these fossils afresh, with no preconceptions derived from the published descriptions or figures, I quickly decided that there were really only two structures well enough defined to offer any possibility of a clear decision as to what they actually were. These were the organs described by Hirst and Maulik (*l.c.*) as the *palp* and the *mandibles* respectively. The supposed *palp* is best seen on the right side of the specimen shown as fig. F of Plate VII in Hirst and Maulik's paper, while the *mandibles* are most complete in the specimen shown as fig. A of the same plate.

Text-fig. 1 shows this latter specimen as drawn by myself (originally at a magnification of 350 diameters) by means of a camera lucida. Comparing this figure with fig. A of Plate VII of Hirst and Maulik's paper (figure drawn



Text-fig. 1.—*Rhyniella praecursor*, Hirst and Maulik. Head-capsule, holotype (× 210): *i*, incisor area; *m*, molar area; *md*, mandible; *p*, pedicel of hypopharynx; *sc*, scape of antenna.

by Miss Violet Borrow), we notice one or two slight differences. I could only establish clearly the presence of two segments of the appendage on the left-hand side, the more distal one lying at a very distinct optical level from the basal one, and quite possibly detached from it. Close to the left-hand anterior border of the head capsule I found a row of four small circular dots, which are either the sockets of small sensory hairs or possibly remains of minute tubercles. No sign of similar structures can be seen elsewhere, but it is evident that the chitin of the head-capsule has been worn very thin and is considerably decayed.

The most important structures in this specimen are the elongated mandibles (*md*). The right mandible is in its normal position, but the left is displaced so that a view of the inner surface is obtained. Thus we are fortunate in being presented with two very distinct views of these organs in the same specimen. The mandible is much elongated and its distal end is divided into distinct *incisor* (*i*) and *molar* (*m*) areas. The latter, however, shows no sign of definite teeth, and only very slight irregularity of the actual grinding surface.

This arrangement is evidently a very primitive one, reminding one rather closely of the structure of the mandibles of MACHILIDAE. But the general form of these organs, and in particular their elongation and retracted position within the head-capsule, strongly suggests that they are Collembolan.

On the inner side of the basal portion of the left mandible can be seen a long, subtriangular plate of thin chitin, the outline of which is not very easy to determine exactly. The form and position of this plate suggest that it may very probably be the elongated *pedicel* of the hypopharynx of a Collembolan, of which, perhaps, the main portion has become displaced beneath the left mandible, through the softening and decay of the head-capsule.

Text-fig. 2 shows the four-segmented appendage on the right-hand side of the other head-capsule shown in Plate VII, fig. F, of Hirst and Maulik's paper. I have made a very careful study of this important organ, paying particular attention to the actual form of each segment and the condition of the sutures between them. The result is of great interest. There can be no

TEXT-FIG. 2.—*Rhyniella praecursor*, Hirst and Maulik. Right antenna, paratype (× 210). *d*, the two partially separated segments of the distale; *pd*, pedicel; *sc*, scape.

doubt, both from the position of the organ, its direct attachment to the head-capsule, and its segmentation, that it is not a palp at all, but a four-segmented antenna of typical Podurid form (Order Collembola).

The *scape* (*sc*) is short, about as long as wide, and clearly inserted on a very slight prominence of the chitin of the head-capsule itself, in such a position as to be pressed down upon the elongated basal portion of the right mandible below it. There is a very distinct suture between scape and *pedicel* (*pd*); the latter, one-third longer than the scape, and slightly wider distally, is remarkable in having the third segment slightly retracted into it, so that the apical margin is markedly infolded and projects out around the base of that segment. The third and fourth segments together form the *distalia* (*d*), or perhaps, more correctly, a single *distale* only imperfectly divided into two secondary segments, for the suture between these is very indistinct and by no means as clearly marked as the other two sutures. The total length of this portion is three-fifths of the whole antenna, and the basal portion of the *distale* is somewhat longer than the distal. The oval apex of the end segment is quite typical of the Podurid antenna. I could find no trace of any of the sense-organs; but this is not surprising, when one considers the condition of the fossil.

It seems scarcely worth while trying to refute categorically the supposition that this organ might be a true palp, but the following considerations might be mentioned. If it were a labial palp, then the insect must be a Hymenopteron or Protohymenopteron, since it is only in the Hymenoptera that these organs have four segments. If, on the other hand, it be a maxillary palp, then the number of segments is again a stumbling-block, for the number found in most primitive insects is usually five, while the MACHILIDAE possess seven and the JAPYGIDAE only two. In those LEPISMATIDAE where a reduction from five to four segments occurs in the maxillary palp, the suture between the third and fourth segments is very marked, and the whole form of the organ very distinct from what is here seen. All these considerations, coupled with the fact that the organ is evidently inserted into the head-capsule and not into part of an appendage, make it clear that we have to deal with an antenna rather than a palp.

Having come to the conclusion that we had, in these fossils, remains of the head-capsule of insects closely resembling the Collembola, and in particular the PODURIDAE, I wrote to Dr. G. H. Carpenter, Keeper of the Manchester Museum, and enclosed my drawings for his opinion. I give the following extract from his reply :—

" I am very much interested in your drawings of Hirst's *Rhyniella*. When I saw his paper some time ago, his drawings suggested Collembola to me, and yours confirm the impression. The four-segmented appendage shown in fig. F is more like a Podurid feeler than anything I know. Several Podurid genera show a similar indistinct joint between the third and fourth segments and a suggestion of ' telescoping ' at the second joint where the cuticle is flexible and the base of the segment can be retracted. The shape of the segments is strikingly reminiscent of a typical Podurid feeler. I should not like to guess at a generic relationship without knowing further details. Then the objects seen in fig. A are just like Collembolan jaws in position (retracted), and, so far as they go, in form. The right-handed one is like a mandible of typical form with molar area and apex (though teeth are not seen). On the left there is apparently the other mandible in a rather different position from the right one, and the long tapering ' foot ' of the hypopharynx. What do you think of the four dots near the margin of the head? If they are ocelli, they do not fit in with the Collembola, where, as you know, these organs are well back behind the base of the feeler, on the dorso-lateral aspect of the head. If they are granulations of the cuticle, they confirm the Podurid affinities of the fossil, but they ought to be all over the surface."

Dr. Carpenter is recognised as one of the leading experts on Collembola, and I am glad to be able to quote him so definitely in support of the interpretation of these obscure fossils given in this paper.

One may note also the exceedingly small size of these fossils, which practically precludes anything except the early larval stages of larger insects, such as the Thysanura, from consideration. My measurement for the total length of the head-capsule in text-fig. 1, from apex to the posterior end of the pedicel of the hypopharynx, is 0·314 mm. The total length of the antenna in text-fig. 2 is 0·254 mm., made up as follows: scape 0·037 mm.; pedicel 0·054 mm.; basal portion of distale 0·086 mm.; distal portion of distale 0·077 mm.

Text-fig. 3 shows my own drawing of the pair of jaws figured by Hirst and Maulik in Plate VII, fig. K, of their paper. The general appearance of these jaws is strongly suggestive of their being the mandibles of some insect of mandibulate type far removed from the Collembola. But they are altogether

too thin and plate-like to have been the jaws of a well-grown insect of this kind, and they suggest to my mind the jaws of some very young larval form. My drawing does not agree very closely with that of Hirst and Maulik, and I was not able to make out clearly the more or less regular series of teeth which they show on both jaws. On the contrary, as far as I could see, the two jaws were markedly asymmetrical, the right one having, on the basal two-thirds of its inner margin, an almost straight cutting-edge which appeared to be made to fit into a distinct notch or slit on the corresponding portion of the left mandible. Both mandibles possess two apical teeth, deeply divided, as if they were almost separate plates or laminae; the more basal of these on the left mandible appears definitely bifid, as if notched to receive the apex of the corresponding tooth of the right mandible. The bases of the two mandibles are markedly asymmetrical, the separation of the adductor and abductor areas being much more marked in the right than in the left, this again suggesting the much stronger action of the right jaw with its cutting plate. A remnant of the insertion of the adductor muscle of this jaw can apparently be made out with careful manipulation.

TEXT-FIG. 3.—*Rhyniognatha hirsti*, n.g. et sp. Mandibles (× 250).

Hirst and Maulik, while giving generic and specific names to the four head-capsules discovered by them, figured this latter pair of jaws and some of the surrounding problematical structures without naming them. It seems to me that if one lot of fossils deserves a name, so does the other, if only to facilitate discussion and to focus attention on the great phylogenetic importance of the discovery of insect remains so far back in geologic time. I therefore suggest the name *Rhyniognatha hirsti*, n.g. et sp., for the specimen shown in Plate VII, fig. K, of Hirst and Maulik's paper, and I offer the following definitions of the two genera *Rhyniella* and *Rhyniognatha*, n.g., as far as they are known :—

Genus **RHYNIELLA**, Hirst and Maulik, 1926.

A genus of strongly-marked Podurid affinities, distinguished by the form of the mandibles, which have molar and incisor areas strongly separated, almost as in MACHILIDAE, with no definite dentition of the molar area, and by the form of the antenna, in which the distale is only imperfectly divided into third and fourth segments, and is slightly telescopically inserted into the pedicel.

Genotype: Rhyniella praecursor, Hirst and Maulik. Types in British Museum. In view of the four head-capsules possibly not belonging to the same species, it would be as well to designate the most complete specimen (that shown in Plate VII, fig. A, in Hirst and Maulik's paper) as the holotype,

and the remainder as paratypes. If further specimens are discovered, differences may be found in the form of the antennal segments sufficient to justify separation into more than one species.

Genus **Rhyniognatha**, n.g.

(Text-fig. 3.)

Portion of the head of a small insect, showing the two mandibles and some surrounding structures. Mandibles asymmetrical, of definite mandibulate type, each furnished with two strong incisor teeth distally, deeply cleft, sub-laminate; left mandible with the more basal tooth bifid. Right mandible with a long, nearly straight cutting-edge occupying the basal two-thirds of its inner margin and formed to fit into a cleft or notch on the corresponding portion of the left mandible. General form of mandibles rather laminate, not very heavily chitinised. Adductor and abductor areas of base of right mandible much more markedly separated and more strongly developed than those of left mandible.

Genotype: Rhyniognatha hirsti, n. sp. (as described above in this paper; length of right mandible from apex to abductor insertion, 0·17 mm.). Holotype in British Museum. Dedicated to Mr. Stanley Hirst, its discoverer.

Note on the Phylogenetic Significance of these Fossils.

The discovery of undoubted insect remains in Devonian strata is an outstanding event in the progress of our knowledge of the evolution of the Insecta. No true insect remains are known otherwise, earlier than the Lower Upper Carboniferous. If Handlirsch's theory of the Origin of Pterygotan insects direct from Trilobites is correct, with the corollary that the Apterygota are a debased offshoot of later origin, we could scarcely expect to find any forms with Collembolan affinities so far back as the Devonian. I think that we may legitimately claim that the genus *Rhyniella* is Collemboloid, if not actually Collembolan or actually Podurid. It seems very unlikely that the thorax or abdomen of any of these fossils will ever be found, judging by the macerated condition of the head-capsules so far discovered. Until we know the actual condition of the segmentation of the abdomen, it would perhaps be unwise to place the genus definitely within the Collembola. The form of the molar and incisor areas of the mandible suggests strongly to me that we have, in *Rhyniella*, a type which is definitely nearer to the Thysanura, and particularly to the Machilidae, than any existing Collembola. That being so, *Rhyniella* may well have been a Protocollembolan, with more than six segments in the abdomen. In any case, I think we may legitimately make the claim that *Rhyniella* belongs to a group which was definitely ancestral to present-day Poduridae and very probably to the whole Order Collembola as we know it to-day.

Comparative morphology almost compels us to believe that, alongside such a specialised type as this, primitive Thysanuran types must have existed in their suitable habitats, though not necessarily in the same habitat as *Rhyniella* itself. The presence of *Rhyniognatha* suggests, though it does not absolutely prove, that some minute early progenitor of the mandibulate Orthopteroid groups was also evolving at this time, but whether it had advanced any distance towards the Pterygotan stage we cannot tell.

The structure of the antenna in *Rhyniella* raises the interesting problem of the original form of this organ in the Insecta. It is here suggested that the Insectan antenna was originally *three-segmented*, each segment serving a different

function. The basal segment, or *scape*, carried the insertions of the antennary muscles, but no sense-organs. The second segment, or *pedicel*, carried an internal organ known as *Johnston's organ*, composed of a number of sensillae developed in close relationship with the antennal nerve. The third segment, or *distale*, carried the external sense-organs for reception of certain delicate vibrations from the outer world; but these must have been originally sufficiently generalised to allow of the evolution of the numerous specialised conditions now existing, from a single original simple type.

If this be the case, then the first two lines of specialisation of the antenna as a whole would be (*a*) its quick reduction and final loss in the Protura, and (*b*) the subdivision of the distale into two segments in the Collembola. Unless the original antenna were a small organ with few segments, its complete elimination in Protura would be hard to understand. The condition seen in *Rhyniella* is a stage in which the subdivision of the *distale* is partially accomplished. The great majority of larvae of Holometabola have very short antennae, mostly with only three segments, and it may be that this again is the original condition preserved in the larval stages in these groups, and not a specialised condition at all. The subulicorn antennae of the Plectoptera and Odonata would be a slightly more specialised stage in which the distale had undergone a certain amount of subdivision into more or less distinct secondary segments. The Orthopteroid stage, in which the distale becomes elongated into a tactile flagellum with numerous secondary segments, would be a higher specialisation correlated with the original active terrestrial habits of these insects.

A further suggestion may be made. Before the Devonian, the ancestors of Plant-life dwelt in the sea, and the ancestors of the Insecta were almost certainly marine and lived alongside them, possibly feeding on them. When the plants came out of the sea and began to live on the land, they had to adapt their respiration to their new mode of life, and developed stomata in their upright, pencil-like stems, before they evolved any leaves. It does not require any great stretch of imagination to see an analogous adaptation to new surroundings in the case of the spiracles and tracheal system of the first true Insecta, though we might perhaps be willing to grant that, in their case, a longer period may have elapsed in which respiration was effected directly through the soft cuticle, in a moist atmosphere, than would be possible in the case of a terrestrial plant. It would seem highly probable that the first step in the evolution of true insects from some marine form of Arthropod was taken through an ecological association with the special group of plants which first made good their footing on the dry earth; most probably the Arthropods fed on the plants, and evolved with them, changing their mode of life and their form as their food-plants changed theirs. From this simple beginning, through many millions of years, a closer and closer association of the two great groups of plants and insects has gradually grown up, culminating in some of the most perfect and wonderful adaptations of living organisms to one another, for mutual benefit.

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POLYMORPHISM IN HORNED BEETLES

By Gilbert J. Arrow.

[Read March 21st, 1928.]

Plate V.

The extreme variability of the horns of beetles, as of the mandibles of male Stag-beetles and all such secondary sexual features, must be well known to all who have studied them even casually. From a good series of examples of any single species it can easily be seen that the size of the horns depends upon that of the individual bearing them, the dimensions increasing, not in simple proportion, but in a rapidly increasing ratio. Champy has shown that this rule applies practically throughout the Animal Kingdom, the proportionate weight of the appendage, variable though it is, to that of the body being mathematically fixed.

These structures therefore are not independent features, capable, as Darwin supposed, of being improved, through Sexual Selection, without regard to any other feature. The selection of the largest males would be the same in effect as the selection of the best-horned, and *vice versa*. Moreover, the increase of the horns being much greater than that of the body of the insect, the supposed selection upon non-utilitarian principles must, if long continued, lead to the destruction of the species. In some of the most remarkable forms of horned male the displacement of the centre of gravity must already be a hindrance to progression and, if development were carried much farther, first flight and ultimately all progression would become impossible.

But the variations of form of these structures are no less striking than the variations of size, and much less simple, and these have received practically no attention. In many cases only a simple progression in size occurs, and changes of a different character have commonly been taken as a sufficient indication of specific difference; but in many cases when considerable numbers of specimens have been compared this interpretation has been found incorrect. Sometimes a gradual transition can be traced from one phase to another which at first appeared to be quite distinct; in other cases no transitional stages have been found, but there are sufficient grounds for believing two different forms to be only different phases of male associated with a single female form.

I have previously recorded a few isolated instances of dimorphism in horned male beetles. Others have since become known to me, and I propose to bring together here all that I am able to put on record. The number of known instances of the kind is not at present large, but it will no doubt be larger when long series of specimens of more species are available for comparison. The study of these facts should ultimately result in the discovery of principles which will throw light upon a variability which at present appears quite without order.

A striking case of male dimorphism is found in an East African Coprid, *Heliocopris hamifer*. Typical males have a short, slender horn rising from the middle of the head and a long one upon the thorax directed straight forward, with a strong tooth beneath (Pl. V, fig. 13). But other specimens are found in which the head has instead a wide transverse ridge, elevated at each end, and

the thorax has a broad, horizontally forked process without any tooth beneath (*jupiter* phase, Pl. V, fig. 14). Specimens to some extent intermediate between these two phases are sometimes found.

In the very common Rhinoceros Beetle, *Xylotrupes gideon*, which ranges from the Himalayas to Australia, the horn upon the head of the male sometimes bears a single tooth near the middle (Pl. V, fig. 1) and sometimes has none (fig. 2). But here it is a case of two geographical races. A tooth is found in well-developed specimens from India and the Malayan Region, Borneo, Java and Sumatra, but not in specimens from farther East, from Celebes, the Papuan and Pacific Regions and Australia. In examples of poor development from any locality no tooth is found, so that the two forms cannot be absolutely distinguished, but when a tooth appears it is always a mark of the Western race.

A similar but more striking case occurs in another allied insect inhabiting the Malayan Region. An extraordinary insect, known as *Trichogomphus lunicollis* (fig. 11), with an immense broad dorsal horn in the male, is found in the Malay Peninsula and Sumatra. Another, called *T. alcides* (fig. 10), in which, instead of spreading out laterally, the horn is produced straight forward, occurs in Borneo. But I have found that examples of less development from both areas are alike, the horn being neither very broad nor very long (fig. 9), and, as the females (fig. 12) are quite indistinguishable, *Trichogomphus lunicollis* and *alcides* must be regarded as two geographical phases of the male of a single species.

These two insects belong to the Dynastinae. A similar case is found in one of the largest of the Coprinae, *Heliocopris gigas*, L. (fig. 4), of which the male is one of the most remarkable insects in existence. Large examples of this bear five horns or processes, two rising perpendicularly from the sides of the head, two projecting forward from the front angles of the thorax, and a great dorsal process springing from the middle of the back.

Heliocopris gigas is generally regarded as an African species. It inhabits the eastern side of the continent from Egypt to the Transvaal. In India is found *Heliocopris midas*, a similar form, in which the dorsal horn of the male is squared at the end instead of rounded, the lateral thoracic processes are sharp instead of being cut off obliquely, as in the African form, and the head has a sharp process in front of each eye. The Indian form also does not attain so large a size as the African. The largest specimens of the latter, however, are only found in the southern extremity of its range, and as we follow it northwards we can observe a tendency in the processes to change their form in the direction of those of *H. midas*. Typical specimens of the latter are to be found in the Gangetic plains, but westwards there is a gradual change towards the *gigas* type, and Arabian and Egyptian examples completely link together the two phases. Females from all localities are practically indistinguishable. Here again, then, is a single species the males of which form geographical races. The earlier name *gigas* was originally given by Linnaeus to the female, so that it is quite suitably applied to the species as a whole.

The forms just described are those of the well-developed specimens of the species in each locality, but these do not exhaust the polymorphism of *Heliocopris gigas*. Although the maximum size reached is greater in South-east Africa than anywhere else, the insects vary greatly in size everywhere, and the degree of development of the horns depends, as always, upon the size of the individual. In the smallest males (fig. 3) the five processes have disappeared, except the dorsal one, which is scarcely larger than in the female; but in such

specimens a new feature appears. Upon the top of the head is found a transverse rectangular plate with sharp angles, which is quite absent in large specimens. This phase has no relation to the habitat, but occurs in Africa and Asia alike. The appearance of the ridge is correlated with the disappearance of the horns. When the head-horns are almost, but not quite, absent, forming small teeth upon the outer edges, the sharp angles of the ridge form two similar teeth, so that there are four equidistant teeth in a line upon the head. We can therefore recognise three forms : 1, With two long external horns and no carina ; 2, With four short horns ; 3, With internal carina and no external horns.

In another Indian *Heliocopris*, *H. dominus*, Bates, exactly similar phases are found, large males with two long horns, intermediate-sized examples with four short horns, and small specimens with a rectangular plate only. The four-horned phase of *H. dominus* was the first-described phase, and the two-horned form, when discovered later, was described as a distinct species by Sharp, with the name *H. mouhotus*. Sharp afterwards suggested that the two forms might belong to a single species, the two small horns on each side in the four-horned phase coalescing to form a single large horn in the other form. This is not the true explanation, for, although the large lateral horns have two cusps at the end, these show no tendency to separate, and may be still traceable in the outer horns when inner ones also are present. I believe the true interpretation to be that in dwarfed specimens there is a reversion to a primitive type. Although of a slightly different shape, a ridge occurs in the same situation upon the head of the females of both *H. gigas* and *H. dominus*, so that it would be approximately correct to say that as the features distinctive of the male diminish the female armature makes its appearance.

In the cases so far described the different forms of male in each species, although at their highest development they may be strikingly dissimilar, are linked together by intermediate stages which, if a sufficiently long series were examined, would probably be found complete. But there are other cases in which no transitional state seems to exist between the different phases. A series of related species of the genus *Onthophagus* seems to be of this kind. This genus is remarkable for containing a variety of types of well-developed armature in insects of very small size, which is quite unusual.

In a West African species, *Onthophagus bidens*, the male, in what may be called the fully-developed phase, has a very long and slender horn upon the head. This is curved and directed backwards, the curvature corresponding with that of the thorax, upon which the horn rests when the head is raised. The female has two much shorter horns pointing laterally in opposite directions, and, in correspondence with these, her thorax is of quite a different shape. It is hollowed out on each side and the middle part projects forward abruptly. There is a third form, a male phase apparently found in about equal numbers with the first, and of about the same average size. In this phase there is a single horn on the head, but it is very short and conical, not reaching the thorax. The latter, instead of the gently rounded surface of the normal male, has the median process and lateral hollows of the female. The two horns, to which this form of thorax appears to be an adaptation, never occur in the male. The two-horned female *bidens* is found sometimes in company with the long-horned male and sometimes with the short-horned form (which has been given the name *tubericollis*). In some localities both male forms occur together ; from others I have seen only one. Amongst over thirty males, although in the long-horned form the length of the horn varies with the size of the specimen, there is no transition in the shape of the thorax.

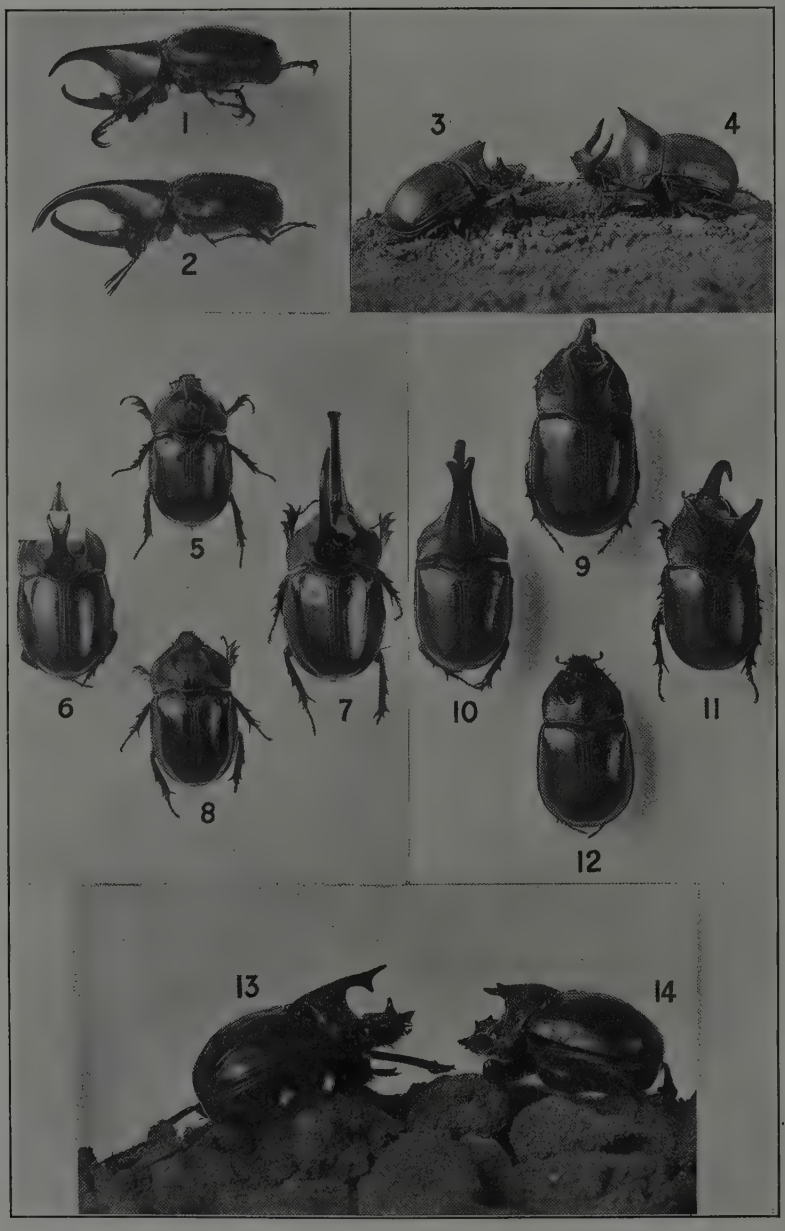
A related species in Ceylon, *O. turbatus*, has three exactly similar forms, and a third in Northern India, *O. mopsus*, is the same, but in this the long-horned form varies very little in the length of the horn, which is extremely long and threadlike. In a third Indian species, *O. spinifex*, the second male form, instead of the very slender horn of the normal male, has a transverse ridge upon the head like the female, as well as the prominence upon the thorax found in all these short-horned male forms.

All these species of *Onthophagus* are very abundant, and I have examined hundreds of specimens, but, although all the three forms vary within certain limits, they remain quite distinct and I have not in any case been able to form connected series. As there is no distinct difference of size correlated with the two male forms, we may perhaps regard the appearance of the thoracic process as compensation for the disappearance of the head-horn.

A very striking case, which may be classed with those just described, is that of a large tropical American Dynastid, *Enema pan*, F. The female (fig. 8) of this is horned, bearing a long sharp horn upon the head and a very short bifurcated process upon the thorax, and in the normal type of male (fig. 6) both these appendages are found in an exaggerated form, the head-horn being very large and toothed near the middle, and the thoracic horn a massive structure broadly forked at the end. But there is another form of male (fig. 7), which, although it differs remarkably and has long been regarded as a distinct species, *Enema infundibulum*, I believe to be really a phase of *Enema pan*. Specimens of this form are always of large size; the head-horn, instead of being toothed near the middle, is forked at the tip, and the thoracic horn, instead of being forked, as in the normal form, is simple. In considerable numbers of specimens of both forms examined I have never found any intermediate; the two forms are found together from Central America to South Brazil, only a single form of female is known and, a very significant fact, practically no variation occurs in the *infundibulum* phase. A series of males of every species of horned beetle known to me invariably shows various degrees of size and corresponding degrees of horn development, and this is the case with *Enema pan*, of which the smallest specimens differ little from the females, while any increase in the size of the insect is accompanied by a great increase of horn-development. The *infundibulum* phase represents the maximum phase of development, but it is a disconnected one. The reversal of the bifurcation of the two horns is a very remarkable feature.

A few generalisations may be drawn from the facts I have recorded. It is interesting to note that in species in which the female is unarmed the horns of the male tend to dwindle to nothing in the smallest specimens, but when the female is horned the male does not fall below the standard of the female, which varies comparatively little. The tendency to reduction of the male armature must therefore be considered an approach to the female condition rather than a mere simplification. This is confirmed by the cases just described in which the approach is not merely negative, by the loss of male characteristics, but positive, by the appearance of features belonging to the female sex. The reverse condition —that is, the assumption by the female of the male armature—seems never to occur as an occasional phenomenon, although the occurrence of the same armature in both sexes as a normal condition is not at all unusual. This does not accord with the prevailing view that features of this kind, when found in the female, have been acquired by inheritance from the male.

Since the weight of the armature bears a definite relation to the weight of the insect, where more than a single horn is present a principle of compensation



G. J. Arrow, photo. *Vaus & Crampton, Ltd.*

POLYMORPHISM IN HORNED BEETLES.

seems to operate, any reduction of one process not due to diminution of the size of the insect being balanced by development in another direction. This seems sometimes to take the form of reversion to an ancestral type of armature, originally common to both sexes.

The tendency of a horn, whether on head or thorax, to bifurcate horizontally, or to be replaced by a transverse ridge, throws light upon the beginnings of such appendages, which have arisen, not from a single point, but by the elongation of a pre-existing ridge, the earliest development of which seems usually to have been the production of its two extremities, the two processes so formed being brought closer together and finally obliterated as the ridge assumed more and more the form of a horn. The very common occurrence of a ridge in the female representing a horn in the male has the same significance. The ridge from which a horn most commonly develops upon the head is one formed at the line of junction of the clypeus and head, but the margins, front, hind or lateral, may also give rise to such processes. Upon the thorax the commonest place of origin of a horn appears to have been the ridge produced at the front or hind edge of a dorsal cavity, sometimes still present, but which in many cases has disappeared; but here also marginal ridges sometimes provide the beginnings of the process.

Explanation of Plate V.

Fig. 1. *Xylotrupes gideon*, L., male, Malayan phase. Reduced.
2. ,, ,, ,, Papuan phase. ,,
3. *Heliocopris gigas*, L., male, small phase. Half natural size.
4. ,, ,, ,, large phase. ,,
5. *Enema pan*, F., male, small phase. Reduced.
6. ,, ,, ,, large phase. ,,
7. ,, ,, ,, phase *infundibulum*. Reduced.
8. ,, ,, female. Reduced.
9. *Trichogomphus lunicollis*, Burm., male. Reduced.
10. ,, ,, ,, ,, phase *alcides*. Reduced.
11. ,, ,, ,, ,, typical phase. ,,
12. ,, ,, ,, female. Reduced.
13. *Heliocopris hamifer*, Har., male, typical phase. Natural size.
14. ,, ,, ,, phase *jupiter*. ,,

COLLECTED RECORDS RELATING TO INSECT MIGRATION*

By C. B. Williams, M.A.
(Entomologist, East African Agricultural Research Station, Amani, Tanganyika).

[Read March 21st, 1928.]

In continuation of my policy of putting on record the largest possible number of facts relating to insect migration, on which alone can a satisfactory study of the subject be based, I give below a series of new observations that have come to my knowledge since the preparation of my last paper in the *Bull. Soc. Roy. Ent. Egypte*, 1926 (1927), pp. 224–256. A few of the observations are my own, but the majority have been sent in by correspondents, whom I take this opportunity of thanking.

The first record, although unfortunately incomplete, is of special interest in connection with the problem of southward autumn flights.

The following notes are discussed :—

(1) *Vanessa cardui* entering Egypt from the North.
(2) *V. cardui* in Transjordania in April 1926.
(3) *V. cardui* in Palestine in April 1926.
(4) *V. cardui* in Mediterranean in September 1926.
(5) *V. cardui* in Isle of Wight in September 1926.
(6) *V. cardui* in South California in March 1926.
(7) *V. cardui* in the Indian Ocean in March 1910.
(8) *V. cardui* in Palestine in April 1927.
(9) *V. cardui* at Port Said in June 1927.
(10) *Belenois mesentina* and *Catopsilia florella* in Kenya in February 1927.
(11) White butterflies in Tanganyika in August 1925.
(12) White and yellow butterflies at Amani in March 1927.
(13) *Belenois severina* in Uganda in April 1922 and May 1927.
(14) *B. severina* in South-east Belgian Congo.
(15) *Belenois java* (?) in Queensland in 1920.
(16) *B. java* (?) in Queensland in December 1911.
(17) *Pieris brassicae, Colias fieldi* and others in Himalayas.
(18) *Catopsilia florella* in Kenya in May 1915 and ? March 1923.
(19) Yellow butterflies in South-west Africa.
(20) Yellow butterflies in the Himalayas in August 1912.
(21) Catopsilias in Ceylon in February 1926.
(22) Catopsilias and Danaines in Madras in 1918.
(23) *Appias lalage* in Bengal in November 1915.
(24) *Teracolus*, spp., at Aden in June 1927.
(25) *Libythea labdaca* in Gold Coast in April 1925.
(26) *Cirrochroa bajadeta* in Borneo.
(27) *Badamia exclamationis* in North Queensland.
(28) *Andronymus neander* at Amani in April 1927.
(29) Brown butterfly in North California in 1924.

* Contribution from the East African Agricultural Research Station, Amani, Tanganyika.

(30) Butterfly in Nigeria in December 1919.
(31) Butterfly in Eritrea in September.
(32) Catopsilias and Danaines in Ceylon in 1926–1927.
(33) Migrations at Amani in 1904–1906.
(34) *Urania fulgens* in Costa Rica in March 1917.
(35) Swarm of moths at Thursday Island in May 1902.

(1) Vanessa cardui entering Egypt from the north in the autumn.

One of the most important points that requires settling in the study of the migration of butterflies is the question of whether or not *V. cardui* has a return southward flight in the autumn (see *Nature*, CXV, 1925, p. 535). Although there are several hundred records of the spring flight more or less to the north, any information on the possibility of a return autumn flight is conspicuous by its absence.

It was therefore with very great interest that I obtained the following information from Dr. Walter Innes of Cairo, who is a keen naturalist and specially interested in birds. He tells me that for many years past he has been in the habit of staying on the north coast of Egypt at Abukir, a little east of Alexandria, about September, in order to see the immigration of the quails, which come in in large numbers about this time; and he states that on several occasions in several years he has seen Painted Lady Butterflies coming in with the quail at daybreak over the sea, sometimes individually, and sometimes in small groups of as many as half a dozen. Not realising the great interest of these observations, he unfortunately did not note down any exact dates.

(2) Vanessa cardui in Transjordania in April 1926.

Through the kind intervention of Dr. F. S. Bodenheimer, I am able to record that, according to Mr. E. Samuel, there was an immense flight of a butterfly—which was undoubtedly *V. cardui*—towards the north in Transjordania in April 1926. I was unable to obtain further details.

(3) Vanessa cardui in Palestine in April 1926.

Mr. G. E. Bodkin allows me to record that there was a very large flight of *V. cardui* on 16th April, 1926, and several following days along the seashore between Haifa and Acca. All were flying low from a northerly direction. A strong easterly wind was blowing at the time (sirocco). The butterflies were so numerous that a number were caught in the front of the radiator of a car going along the shore. He received reports a few days later that cars proceeding from Palestine to Syria on the same day and on the following day had to stop at intervals and remove large numbers of the butterflies from the radiators. In some cases the entire front of the radiator was covered. On the second day Mr. Bodkin observed large numbers of these butterflies settled round pools of water, apparently drinking.

(4) Vanessa cardui in Mediterranean in September 1926.

On 8th September, 1926, Mrs. R. E. Moreau was on board a steamer out of sight of land and just south of the island of Pantellaria (between Sicily and Tunis). During the morning she saw two *V. cardui* flying over the water near the bow of the ship, and about an hour later one was seen, which, however, might have been one of the previous two. Mrs. Moreau thinks that they were flying in the same direction as the ship (*i.e.* towards east), but is not sure on this point.

I have at present over sixteen records of *V. cardui* crossing the Mediterranean, but this is the latest date for its occurrence. Further autumn records are specially required, particularly with the direction of flight, to settle the disputed question of the possible return migration to the south.

(5) Vanessa cardui in Isle of Wight in September 1926.

Prof. E. B. Poulton informs me that *V. cardui* appeared in numbers at Bembridge, Isle of Wight, on Sunday, 12th September, 1926. It had been seen singly during his visit from middle of August, but in nothing like the numbers that appeared on the 12th September. The wind was very strong and from the south-west. The butterflies were flying along the coast and settling on flowers. The direction of flight at Foreland and between there and Bembridge was from the south and following the curves of the coastline.

This is another addition to the numerous records of flight of this species during 1926.

(6) Vanessa cardui in Southern California in March 1926.

I am indebted to Dr. Mohammed Kamal of the Ministry of Agriculture of Egypt for the following record :—

"There was a quite distinct migration of *V. cardui* at Riverside, Riverside Co., California, on 11th March, 1926, between 10 a.m. and 3 p.m., with maximum about 12–2 p.m. The flight was from east to west in open order, occasionally a few joining up to make a short line. The day was warm. Temperature about 75° F. Sky clear and sun shining. For two days previously there had been light showers. There was a light wind blowing more or less to south. The butterflies must have arrived at Riverside a day or two before, and had been compelled to take shelter from the rain, as many were seen crawling out of the grass in the lawns of the citrus station and taking to flight in the warm and bright sunshine. They flew close to the ground, and practically never at a height of more than 15 feet. In some cases large numbers were stuck on to the radiator of motor cars passing along the roads through the flight."

This flight has already been noted by other observers, but every additional note is of interest.

(7) Vanessa cardui in the Indian Ocean in March 1910.

Mr. T. Bainbridge Fletcher allows me to record that on the 27th March, 1910, at 8.30 a.m., a *V. cardui* settled in an absolutely exhausted condition on a P. and O. steamer (London to Calcutta) when in Lat. 9° 50′ N. and Long. 67° 40′ E. The nearest land was the island of Minikoi, just north of the Maldive Islands, about 320 miles away to the east. The sea was very calm and smooth and there was a very faint north-east wind.

(8) Vanessa cardui in Palestine in April 1927.

Dr. F. S. Bodenheimer informs me that on the 9th April, 1927, a friend of his, Mr. Danin, saw a large flight of *V. cardui* from 10 to 12 a.m. at Beersheba, Palestine, flying towards the south-east.

(9) Vanessa cardui flying out to sea at Port Said.

It is perhaps worth putting on record that the only specimen of *V. cardui* that I saw during a stay in Port Said, Egypt, from 7th to 14th June, 1927,

was about 10 a.m. on the 8th June. I was bathing at the time, and the butterfly was already over the water, and disappeared out to sea, flying steadily to the north against a light wind, a few feet above the water.

(10) **Belenois mesentina and Catopsilia florella in Kenya Colony in 1927.**

In February 1926 there was a very large flight of *B. mesentina* through the Nairobi District of Kenya, chiefly towards the south-east (see *Bull. Soc. Roy. Ent. Egypt*, 1926, pp. 243–251).

In 1927 there was another flight, but on a much smaller scale. I have received two accounts of this flight—for one of which I am indebted to Mr. T. W. Kirkpatrick, and for the other to the Rev. K. St. A. Rogers.

Mr. Kirkpatrick writes as follows, from Nairobi, 25th February, 1927 :—

" During the last few days there has been a small migration of *B. mesentina*. I am told it started before the 17th, but I was away from Nairobi until then, and I can't find out exactly. The only interesting thing about it was that, although the climatic conditions were almost exactly the same as last year (temperature perhaps a little lower when I saw the migration, though it was said to have been very hot just before I got back, and the wind exactly the same, *i.e.* constant north-east), the butterflies were flying to W. to W.N.W., *i.e.* at the same angle to the wind as last year, but on the opposite tack ??. The numbers when I saw them were not one-thousandth of those of last year, but it was a distinct migration."

Canon Rogers, writing from Voi, between Nairobi and Mombasa, and about 200 miles from the former and 100 from the latter, on 2nd March, 1927, says :—

" We have had the usual migration of *B. mesentina* here this year, but on a smaller scale than usual. I noticed the migration first on 10th February, the direction was from N.N.W. to S.S.E., as far as I was able to observe, but this is a jumbled mass of hills, with deep, steep-sided V-shaped valleys, the highest points of the hills rising over 7000 feet, the plain being about 2000 feet. The weather was very dry and hot, probably up to 90° F. on sunny days, but I have no thermometer here. The migration required looking for on most days, and continued for about ten days. The only day on which the migration forced itself on one's attention was the 16th, a cloudy day with sunny intervals, when the number crossing a line 50 yards long sometimes rose to fifty per minute. During the morning very little movement could be observed, though the butterflies were flying about and feeding freely, but about midday the migration became marked. I should add that both sexes were involved, and the average size seemed to be small. *B. mesentina* is resident in this district."

Later Mr. Rogers gave me the following additional notes on flights at Dabida in the Taita Hills near Voi :—

7th March (1927). A small but distinct migration of *B. mesentina* commenced from S.S.W. to N.N.E., the wind being N.N.W.

8th March. A few butterflies still migrating in the same direction, the wind being fresh.

16th April. *C. florella* migrating from north to south, females being apparently in the majority.

19th April. *C. florella* still migrating, but individual females observed ovipositing.

22–25th April. *B. mesentina* migrating from south-west to north-east.

He also writes that in the latter part of March there were indications of a

migration of *B. mesentina* from west to east, but hardly sufficiently definite for record.

It will be seen below (No. 12) that these two species were almost certainly concerned in a flight at Amani in N.E. Tanganyika towards the end of March.

(11) Migration of Butterflies in Tanganyika.

In the *East Africa Standard*, published at Nairobi, in a number issued about the end of March 1926 appears a letter from Mr. T. L. Priestnall, which contains sufficient information to be worth more permanent record.

He writes: "On August 25th, 1925, I saw clouds of these butterflies pass over Thunt [sic], between the hours of 9 and 3.30. They were 25 to 100 feet up, approximately, and flying dead east from west. They were very scattered for the first two hours, but after that for three hours they blotted out my view beyond 100 yards. None settled here. On the 26th they came again, going in the same direction, and I called my wife to see them. It was similar to looking at snowflakes. I spoke to a gentleman who works here, and he saw the same sight two hundred yards down the valley, and from what he states of the date it is approximately the date in my diary. He also states that they reached the full length of the valley, which is about one mile long, running north to south, and the butterflies were all going due east. Another employee here saw another flight about one month ago, all flying north."

The letter is dated 13th March, 1926, from Thumi, Tanganyika, but it appears that both this and "Thunt" above are misprints for "Shumi," which is about 7000 feet up in the West Usambara Hills, N.E. Tanganyika.

From the remarks about the resemblance to "snowflakes," it is probable that the butterflies were PIERIDAE, and the last sentence, referring to a flight in February 1926, may possibly refer to *B. mesentina*, as this species was making huge flights in Kenya in the first half of February.

I am indebted to Mr. C. J. F. O'Brien, Senior Agricultural Officer of Tanganyika, for bringing this letter to my notice.

(12) Migration of White and Yellow Butterflies at Amani, Tanganyika.

Mr. Wm. Nowell kindly gives me the following record :—

"On 23rd March, 1927, at noon I observed a west to east migration of butterflies past my house at Amani. They were chiefly a small species, about the size of the English 'Small White,' with some larger sulphur-coloured ones and a few spotted of more than one species. One was predominantly fawn in colour. The average for the first fifteen minutes observed was about six to ten per minute within easy reach of sight. There were some lulls, and then as many as eight to ten passing at once. There was bright sun with an occasional light breeze from the south. At 4 p.m. odd stragglers were passing the same route. Movement in the same direction was observed on the two following days, but more irregular and in smaller numbers."

Although no specimens were taken, there is little doubt, in view of other records in the district, that the small white species was *Belenois* sp. and the larger sulphur species *Catopsilia florella*.

It will be seen above (p. 82) that *B. mesentina* was migrating in Kenya in February 1927, but Mr. Nowell was not at Amani in that month, so it is not known if that migration extended this far.

The migration at Amani occurred in a short dry spell after the first heavy

rains of the wet season. The 2 p.m. temperatures were 26–27° C. (80–82° F.). For further details see p. 89.

(13) Belenois severina migrations in Uganda.

Mr. H. Hargreaves, Entomologist to the Department of Agriculture of Uganda, allows me to record that about mid-April 1922 there was a migration of *Belenois severina*, together with *Terias marshalli* and some other Pierids, towards the south-east at Kampala, Uganda. The flight lasted for several days and occurred in the wet season.

Mr. G. L. R. Hancock, Assistant Entomologist, allows me to record that from 3rd to 14th May, 1927, *Belenois severina* was again migrating at Kampala, this time towards the west. The flight lasted all day, ceasing about 5 p.m. or during unfavourable weather. The prevailing wind was from the south, and light. The season was about the third week of the rains, but the previous weather had been on the whole unusually dry. On 3rd May from 1.6 to 1.21 p.m. forty were counted passing in the fifteen minutes, and from 1.24 to 1.34 p.m. 320 passed, of which sixty-nine were noted as females. On the whole the males outnumbered the females about three to one. One female dissected was found to be full of eggs.

(14) Belenois severina in the Belgian Congo.

Monsieur Ch. Seydel kindly sends me the following information :—

"I have noted on several occasions, having lived there four years, in Elisabethville in the Katanga, large numbers of specimens of *Belenois severina* to cross the town during the daytime from west to east. As I did not at the moment take a special interest in this phenomenon, I have taken no record of the matter. All I remember is the time of the year, viz. November, and that the migration used to start during the forenoon somewhere about ten o'clock and lasted sometimes till 4 or 5 p.m."

Elisabethville is in the extreme south-east of the Belgian Congo.

(15) Pierid migration in Queensland.

Mr. W. L. Puxley gives me the following record :—

"A most interesting flight I witnessed while staying in the Glasshouse Mountains, Queensland, in 1920 was that of a species of Pierid, and during the spring of that year (*i.e.* about September) they began to fly over the gum trees in that district in such multitudes that the whole air was darkened by them. When approaching they looked like locusts on the wing, but presently they were seen to be white butterflies with yellow spots beneath. Great numbers of parrots and lories were following them and feeding upon them, and sometimes a specimen fell to the ground, but the rest continued their flight hour after hour till darkness prevented my seeing if the host passed on through the night. This continued for nearly three weeks from dawn till dark, at least, so an idea of the numbers may be guessed at. I did not go far, but as far as I could go in difficult and swampy country the butterflies were darkening the air, making for the north-east, as far as I could judge. Then after three weeks the flight was over, and scarcely a butterfly could be seen except for a rare straggler, and these ceased altogether after a day or so more.

"I was told by residents that these flights are not annual unless in far smaller numbers, but only occur about once in four or five years in such amazing numbers. In this case it would seem that the Pierid butterflies bred

in the interior of Australia—probably not far from the east coast, for in the arid interior they could not find supplies for such incredible multitudes. . . .

" The wind was very light during the flight, only a breeze at midday. No such flight occurred in 1921."

There is practically no doubt that the species referred to is *Belenois java teutonia*, F., which answers to the description and has been several times recorded in mass flight in Queensland and New South Wales.

(16) Great flock of butterflies in Queensland.

Mr. Gerald W. Williams informs me that on the 17th December, 1911, on the Leichardt River (about 150 miles north of Cloncurry in Queensland), above Camillaroi station, he saw an enormous flock of butterflies over a big pool of water in the river-bed, which was about one and a half miles long and perhaps 200 yards wide. Over this pool there were millions of butterflies circling or milling like a cyclone round and round up to a height of about 150 feet, and probably 200 or 300 yards in diameter. The time was about 3.30 p.m., the day calm and very hot (probably near 100° F.), and the following night there was a heavy thunderstorm.

He described the butterfly as white with a dark tip to the wing and some purplish colour beneath. It is very probable therefore that the species concerned was *Belenois java*, which answers more or less to this description, and is known to be in the habit of migrating in large flocks in Queensland.

(17) Pieris brassicae and other species in the Himalayas.

Major R. W. G. Hingston kindly allows me to publish the following observation made by him in the year 1919 :—

" At Dharmsala, on the Dhauladhar Range of the Himalaya, butterflies begin to get numerous in March. Towards the end of the month [March 1919] I became aware that they were all moving in the same direction. All belonged to the species *Pieris brassicae*, and all were ascending the range. At that time there were not very many about. In fifteen minutes thirty-seven butterflies flew past me up the slope. The direction they were moving was north-west and straight up to the Himalayan snow-line. There was no hesitation, no alighting on flowers; the butterflies kept close to the ground and never deviated from the north-westerly course. During subsequent days the flow continued, and each day its strength increased. In cloudy weather the flow was checked, but it reappeared in full strength as soon as the sun shone. Otherwise it seemed independent of any climatic change.

" From day to day I observed the migration at an altitude of 6000 feet. By mid-April the flow was very profuse. Hundreds passed me every minute. They seemed to like to ascend along a sheltered ravine, I suppose to escape the wind. The flow was then a remarkable sight, as the hillside seemed white with fluttering wings. *P. brassicae* was the most conspicuous in the migration, and the only species present at its commencement. Later numbers of *Colias fieldi* appeared, and in the end became almost as numerous as *Pieris*. A few *Danais chrysippus*, an occasional *Vanessa cashmirensis*, and a fair number of *Polyommatus boeticus* were seen at intervals mixed up in the stream. . . .

" For at least two months the flow continued, and in that time many millions of butterflies must have ascended this section of the mountain slope. One day when the stream was at its full I followed it upward to the snowline, which then lay at 10,000 feet. At this height the stream was thinner, which

suggests that some of the butterflies may have come to a halt at intermediate heights on the range, possibly at about 8000 or 9000 feet. Nevertheless a fair number of PIERIDAE continued the ascent above the snow-line. I counted thirty-two passing me in half an hour. Also their direction was a little changed, having veered rather more to the north. Certainly thousands of butterflies must have passed daily above the snow-line, where I imagine they were certainly destroyed.

" The explanation of this migration which I formed at the time is as follows. *P. brassicae* and *C. fieldi*, the two conspicuous members of the migration, frequent the Himalaya at considerable elevations, certainly up to a height of 11,000 feet. Now in winter at these altitudes there must be a great destruction of insect life when the mountains down to 8000 feet are deeply covered in snow. Probably butterfly life at 10,000 and 11,000 feet is very largely destroyed. Yet these altitudes in summer abound with butterflies, as the area above the tree line is an alpine pasture covered with quantities of flowers. How are these alpine pastures repopulated with butterflies if it is a fact that much destruction in winter takes place? My idea is that repopulation takes place by migration from lower elevations. Butterflies in the lower valleys survive the winter. At higher elevations there is a depopulated place and one particularly attractive to butterflies. Hence the instinctive impulse to ascend in immense swarms."

(18) Migrations of Catopsilia florella in Kenya Colony.

A. Loveridge (*Proc. Zool. Soc. London*, 1923, p. 71) refers very briefly to some migrations of *C. florella* in Kenya. He says: " Besides the migration of this butterfly witnessed on 3.v.'15, another lasting several days was witnessed in 1919. In both cases the butterflies were going in a north-westerly direction. In the second migration the wind was strongly in their favour, but, if I recollect right, adverse on one somewhat cold day."

I wrote to Mr. Loveridge, and he has given me the following additional information. The 1915 flight was on the plains between Nairobi and Kelbo Farm, about five miles E.N.E. of Nairobi. The 1919 flight was in March or April, and almost certainly early in March; it lasted about a week, and was observed on the hill about $1\frac{1}{4}$ miles W.N.W. of Nairobi station. " Each day the butterflies drifted by in a very open order, about one to 20 cubic feet, but as far as the eye could see. When I reached the office at 9 a.m. they were not so dense, but thickened towards 11 a.m. and thinned towards 2 p.m. Thousands and thousands must have passed."

(19) Flight of yellow butterflies in South-West Africa.

Mr. Gerald W. Williams tells me that, according to the account of a very reliable local game-hunter, there was a flight of yellow butterflies with a black edge to the wing across the Namid desert with an east to west wind in late May or early June 1923. They were proceeding west out to sea just north of Swakopmund, South-west Africa. So far as Mr. Williams knows, no such butterfly breeds in the district, which is very desert.

It is possible that the species referred to is *Catopsilia florella*, though the description would more exactly fit a *Terias* or *Colias*.

(20) Yellow butterflies in Himalayas in August 1912.

Through the kindness of Mr. Watson, I can record that Mrs. Peile wrote in a letter that yellow butterflies (presumably Catopsilias) were flying all in

one direction, about 30th August, 1912, at Masuri (Mussoorie) in the north-west Himalayas.

(21) Catopsilias migrating in Ceylon in February 1926.

Mr. H. Steuart informs me that in second week in February 1926 he saw enormous swarms of yellow butterflies flying along the roads between Trincomalee and Annuradhapur, and also between Trincomalee and Kandy, but only in the northern section of the latter. He does not recollect which direction they were taking.

(22) Catopsilias and Danaines in Madras in 1918.

Mr. G. H. E. Hopkins allows me to record that he saw thousands of Catopsilias and Danaines going north through Madras in 1918, but he is unable to recollect the month.

(23) Appias lalage in Bengal in November 1915.

Dr. C. L. Digby Roberts allows me to record that in November 1915, in the Kalimpong sub-division of Darjiling District, Bengal, he saw a migratory flight of *Appias lalage*. It was seen during a tour from an elevation of 4000 feet, across a spur of 10,500 feet and down to a similar elevation on the other side. A few were even seen in the plain at 1000 feet. The total distance covered by the journey was about seventy-five miles. The butterflies were flying in a general easterly direction throughout the whole day. The flight was thin, but stronger after 4 p.m. The wind was variable, but chiefly easterly. The season was the early cold weather just after the close of the monsoon. Only males were in the flight, not a single female was caught or seen. No other species were in the flight.

(24) Teracolus, spp., at Aden in June 1927.

On 19th June, 1927, I was on S.S. *Tanganyika*, which was off the harbour of Aden about 9.30 a.m. Before entering the harbour we steamed for about half an hour along the coast in a direction more or less a little north of east, and a mile or two from the shore. During this period I noticed a number of butterflies drifting with the wind across the deck from north to south or perhaps N.N.W. to S.S.E., passing at the rate of about one per minute. There appeared to be four or five species, but specimens of only three were captured. These were kindly identified for me by Prof. Poulton as follows :—

(1) *Teracolus calais*, Cram., one of each sex.

(2) *Teracolus physadia*, Godt., one female. About fifteen specimens of these two species were seen.

(3) *Teracolus evagore*, Klug, one male, the only one noted.

In addition to these, two or three were seen that appeared to be a species of *Colias*, several of a larger white Pierid, one of a much smaller species, possibly a Lycaenid, and two or three of a larger very active insect that was about the size of *V. cardui*, but almost certainly was not this.

Although the butterflies were all passing in the same direction across the ship, they had not the determined flight that is typical of most migrations. It is, however, curious to note that once we entered the harbour not a single butterfly was seen on board or in the air round the ship during the rest of the day.

It appears worth putting this note on record, as it may enable other entomologists to watch for a similar occurrence for comparison and confirmation.

(25) Libythea labdaca in Gold Coast in April 1925.

In *Entomologist*, LIX, 1926, p. 171, is a short note on migration of *Libythea labdaca* in the Gold Coast. In reply to an inquiry, Mr. Cardinal sent me the following additional information: "I was in headquarters the other day, and was told that on 10th April of last year (1925) they were so thick that a motor had actually to pull up, as it was impossible for the driver to see his way. This was on a road through the forest. That same month I was out in the forest and watched a flight for several days."

This gives one additional exact date, which is always of value.

(26) Cirrochroa bajadeta in Borneo.

In *A Naturalist in Borneo* (1916), pp. 220–221, Shelford records a mass flight of this species at Kuching.

Dr. C. Hose, who has resided in Borneo for many years, tells me that this species migrates nearly every year between August and October on the coast of the "Miri" Baram district, going to the north-east, just about the change from the south-west to north-east monsoon.

(27) Badamia exclamationis in North Queensland.

In the *Entomologist*, 1926, p. 4, is given a short quotation about migrations of *Badamia exclamationis* from a book *Green Islands in the Glittering Seas*, by W. L. Puxley. In reply to an inquiry, Mr. Puxley gave me the following additional information: "As regards the skipper butterfly mentioned in my book, unfortunately very little is known of its life-history as yet. It is thought to breed in New Guinea, and makes for the 'Dead Heart' of Australia, apparently for very little reason, since there can be little to feed upon there. It remains in Australia for four months (? October to February), but has not so far been seen to breed there. When moving there appear to be countless millions of them, but they vanish suddenly after their annual stay, and I believe have not been found after their annual flight, yet I have heard of no record of their leaving Australia in the same numbers as they arrive."

(28) Andronymus neander at Amani in April 1927.

Mr. Wm. Nowell, Director of the Amani Research Institute, kindly gives me the following notes:—

He returned to Amani, after two weeks absence, on 8th April, 1927. The following day, 9th April, after a very wet morning, he noticed at 3 p.m. a very strong migration of skipper butterflies flying towards the S.S.W. The flight was rapid and purposeful, several hundreds a minute passing the point of observation. The flight continued the whole afternoon. Dr. G. B. Wallace informed him that the movement had been going on for four previous days and was noticed at Mdorema, an estate about four miles away to the E.N.E.

On the 10th the flight continued undiminished from early morning. It continued also on the 11th and 12th without noticeable diminution, but not regular all day. The migration seemed to be more active when the sun was shining. It was also seen at Kwamkoro Estate, about four miles to the S.S.W.

on the 12th. The 13th was dull and rainy at times, and only stragglers were passing. On the 14th and 15th the migration was resumed in full force during the sunny periods of the day. On the 16th, 17th and 18th the butterflies were still coming over at intervals, but in diminishing numbers, the weather being showery with sunny intervals. On the 19th large numbers were passing at 2.30 p.m.

Mr. Nowell captured seven specimens, all of which were *Andronymus neander*. Of six specimens examined four were males and two females.

The climatic conditions previous to and during the flight were as follows. The preliminary rains of the wet season had started about the 6th March, and lasted till the 21st. There was then a slight lull, but the rains resumed again with heavy rainfall (nearly four inches) on the 8th April, and during the period of the flight there was rain nearly every day. The wind was variable. The 2 p.m. temperature varied from 22° to 27° C. (71–81° F.).

Amani is at an altitude of 3000 feet in the East Usambara Hills in North-east Tanganyika, about forty miles from the coast.

(29) Brown Butterfly in California in 1924.

Mr. Kenneth Walker informs me that some time between the 15th August and the 15th September, 1924, he saw a large flight of butterflies in Lassen County, North California. The butterflies were going in a direction a little west of north, and he drove in a motor diagonally through the swarm for a whole day. The locality was at an altitude of about 5000 feet, and he thinks that the direction of the flight might have been affected by the mountain ranges.

He described the butterfly as being about two or three inches across the wings, and with a dark spot on the fore-wings, possibly with a lighter centre.

The only butterfly that, so far as I am aware, has been recorded as migrating in the area at this period of the year is *Vanessa californica*. The rough description might possibly apply to this.

(30) Butterfly in Nigeria in December 1919.

Mr. Gerald W. Williams informs me that about the 20th December, 1919, a butterfly suddenly appeared in great numbers at a place in the Ningi Hills, North Nigeria. There was a butterfly every four or five yards on the path, although for four or five days previously none had been seen in the vicinity. They were still there when he left for Yardekerry, about twenty-five miles to the south, on the 24th December, and they appeared in this latter place about the 28th. The wind was from the north during the whole period, which was very dry. The previous rainy season had been poor.

Mr. Williams described the butterfly as about the size of the common British Tortoiseshell, upperside greyish with a number of white spots, underside rich fulvous brown with shadow spots.

Mr. N. D. Riley suggests that the species concerned was *Libythea labdaca*, which is known to be a migrant in this part of the world. It answers roughly to the description, but for the present it will be better to consider the record merely as an indication of where more observation is needed.

(31) Butterfly in Eritrea in September.

Dr. Walter Innes of Cairo informs me that some years ago in September he was staying at Asmara, Italian Eritrea, and each evening after 4 p.m. there

was a distinct flight of butterflies towards the east. The species was not identified, but this is, I think, the first record for this country, and serves to emphasise the universal nature of the phenomenon of migration.

(32) Catopsilias and Danaines in Ceylon in 1926–1927.

Mr. S. S. Light kindly sends me the following information from Nuwara Eliya, Ceylon :—

" Migration apparently started about a week before 24th November, when first noted.

" 24*th November*, 1926. (1) A number of *Euploea* sp. seen flying from east to west at 2 p.m., flying slowly with the wind about 10-20 feet from the ground. (2) At about the same time in another part of Nuwara Eliya the same species, together with a large sulphur Pierid [almost certainly *Catopsilia* ?] and several other species, including a large Pierid yellow with orange or reddish hind-wings, seen flying from east to west with the wind in lesser quantity than above.

" 25*th November*. As the second record above. The first two species mentioned (*Euploea* and *Catopsilia*), in almost equal numbers, made up the bulk of the flight. Flight decreased in the afternoon; by 4.30 p.m. none were to be seen.

" 26*th November*, 10 a.m. Large numbers as yesterday, flying low, nearly all *Euploea*, sp. Later in the day more *Catopsilia* appeared. Flight stopped before 3 p.m.

" 27*th* and 28*th November*. As before, nearly all *Euploea*.

" 29*th November*. More seen at 9.30. At 10.30 p.m. a few, nearly all *Catopsilia* and other Pierids.

" The flight grew less after this and ceased about the 3rd December, when rainfall occurred. A few *Atella phalantha* were also seen in the flight.

" 17*th March*, 1927. Ran into a flight (steady but not abundant) of *Danais septentrionalis* two or three miles in extent near Haputale [eighteen miles south-east of Nuwara Eliya], flying slightly west of north. Time about midday, clear day.

" 22*nd June*, 1927. Nuwara Eliya. Flight of *Appias venusta* and *A. paulina* almost exclusively, with an occasional *Euploea* flying east with the wind. Began about 11.30 a.m. on a fine day during the south-west monsoon.

" 23*rd June*. Same flight, more abundant than yesterday, began about 10.0 a.m. Another fine day.

" After this date saw no more."

(33) Additional notes on previous migrations at Amani in 1904–1906.

In 1906 Vosseler (*Insektenborse*, XXII, pp. 68–70, 75, 77) published some notes on butterfly migrations that he had seen at Amani in North-east Tanganyika. As the collections of the Amani Research Institute are now in my charge, and as a number of Vosseler's original specimens are still intact, it is possible to give information on the sexes represented, that he omitted to record.

(*a*) Vosseler describes a migration of *Libythea laius* on 11th May, 1904. Eight specimens labelled as captured on this migration are in the collections at Amani, of these six are males and two females.

(*b*) He describes a migration of *Pieris mesentina* in February 1904. Twenty-

one specimens of these are in the collections, of which fifteen are males and six females.

(*c*) He describes a migration of *Asterope* (*Crenis*) *boisduvalli* in March 1905. Of these three males and three females are in the Amani collections.

(*d*) He records a migration of *Andronymus neander* on 19th March, " d.J." From the context it is not quite clear which year " this year " is, but the specimens in the collection show it to be 1906. Of twenty-nine specimens in the collections seventeen are males and twelve females. (For another record of this species at the same place in 1927 see p. 88.)

(34) Urania fulgens in Costa Rica in 1917.

In the *Trans. Ent. Soc. London*, 1920, p. 164, I recorded some notes in migration of *Cydamon leilus* at Suretka, Costa Rica, on 4th March, 1917. On a recent examination of my specimens, which have been stored away in papers since that date, I find that I misidentified the species, which is *Urania* (*Cydamon*) *fulgens*, and not *leilus*.

(35) Great swarm of moths near Thursday Island.

Captain McLean informs me that in 1902, about the end of May, when on a sailing vessel inside the Australian Barrier Reef, near Thursday Island, immense swarms of moths invaded the ship so thickly that they got into the blocks and made it impossible to work. A large bucket-full was given to some natives, who ate them. Is this a near relation of the " Bugong moth " (*Euxoa*? *infusa*), which also swarms in parts of Australia and is eaten by the natives?

ON THE SYSTEMATIC POSITION OF *ANOMOSES* (LEPIDOPTERA HOMONEURA)

By Alfred Philpott.
(Hon. Research Student in Lepidoptera, Cawthron Institute, Nelson, N.Z.)

[Read March 21st, 1928.]

Plate VI.

Through the kindness of Dr. A. J. Turner, who presented me with a specimen, I have been able to examine the genitalia, mouth-parts, neuration, etc., of this interesting archaic species. I learn from Dr. Turner that the original unique example, taken in 1902, has now been supplemented by a fair series secured recently on the Macpherson Range, Queensland National Park. It is proposed here to figure and describe the male organs, and to include certain notes and suggestions with reference to other parts of the insect's structure with the view of throwing additional light on the affinities of one of the most interesting forms discovered within recent years.

The Male Genitalia

The male genitalia of *Anomoses* are characterised by comparative simplicity. The eighth segment of the abdomen is but slightly modified and, under normal conditions, only partly conceals the external genital structure. The tegumen is narrow and membranous dorsally, but expands into rather broad, squarish dorso-lateral plates, which, on their caudal margins, bear a pair of short curved prongs, exterior to which there is a blunt irregular projection. The lateral arms of the tegumen are not continuous with the dorso-lateral sclerites, but are membranously attached thereto. They are broad and fairly regular in outline, and at about half-way of their length are sharply bent caudally. There is thus no suspensorium present, and the prominent and complicated tegumental processes found in many of the Hepialoidea are represented only by the small curved prongs referred to above. The vinculum is broad, with short lateral arms, a ventral plate from the cephalic margin being directed caudally; normally the vinculum is almost hidden by the eighth sternite. The harpes are large and entire; they differ little from those of *Hectomanes polyspila*, Meyr., except that the upper apical angles are produced into points. The juxta is narrow and somewhat Y-shaped; it bears most resemblance to that of some species of *Hectomanes*, *H. fusca* and *H. polyspila*, differing only in the greater lateral extension of weak chitin. Hinged to the apical lateral arms of the juxta is the trulleum, a curved organ with the apical half tapering to a point and the basal part greatly broadened and deeply bifid. *H. polyspila* here again closely approaches *Anomoses*, practically the only difference being the absence of the basal bifurcation in the former. The penis is membranous, as is the aedeagus, though it should here be noted that some students regard the trulleum of the Hepialoidea as equal to the aedeagus of other lepidopterous groups.

From the above study of the male genitalia we may conclude that *Anomoses* is in the main of a more primitive type than the rest of the Hepialoidea. The

eighth sternite is but slightly modified; the harpes are simple and the tegumen has not developed the complicated structure of the suspensorium. In the HEPIALIDAE the eighth sternite is strongly chitinised and forms a flat ventral plate. In the PALAEOSETIDAE the harpes are cleft almost to their bases; in the PROTOTHEORIDAE they are small and finger-like, while in the HEPIALIDAE they are variously modified, only approaching the simple entire shape of *Anomoses* in some species of *Hectomanes*. It is chiefly, however, the comparatively slight modification of the tegumen that constitutes the strongest evidence for the archaic nature of *Anomoses*, all the other groups of the Hepialoidea having this organ highly specialised, a specialisation culminating in the fantastic elongate, curved, paired prongs of the PALAEOSETIDAE and PROTOTHEORIDAE.

THE MOUTH-PARTS.

The labial palpi are three-segmented, of normal shape and of moderate length. The second segment is almost twice as long as the first, and the third is about one-third of the length of the second. The whole organ is covered with rather long scales. No traces of mandibles are to be found, but a reduced and obviously functionless haustellum is present. The latter structure is about half as long as the labial palpi, and is clothed with hairs and scattered scales similar to those on the labial palpi. A minute maxillary palp is present, and is apparently two-segmented, though the division is not well defined.

Meyrick (1920), accepting the observations of Tillyard, characterises the PROTOTHEORIDAE as having "mandibles more or less developed," but dissection of the mouth-parts of *Metatheora corvifera*, Meyr.,* resulted quite negatively as far as these organs were concerned; not the most vestigial trace could be discovered. Nor did a careful examination of Dr. Tillyard's slides of the mouth-parts of *Prototheora petrosema* and an undetermined species reveal the parts. It seems probable, therefore, that some confusion has occurred, and that the PROTOTHEORIDAE are without mandibles.

The possession of an haustellum, although much reduced, at once places *Anomoses* among the more primitive of the Hepialoidea. As far as I am aware, this organ has been completely lost in all genera of the HEPIALIDAE except *Hectomanes*, and even in this genus it is only some of the species which retain it in a greatly reduced condition. In *Palaeoses*, according to Dr. Turner (1922), the maxillae are entirely absent. The PROTOTHEORIDAE exhibit a small haustellum with a two- or three-segmented palp, the organ being rather less reduced than in any other group of the superfamily.

THE ANTENNAE.

The antennae of *Anomoses* are similar to those of the PROTOTHEORIDAE, that is, short, with simple pubescent segments, and of a type quite different from the organs in the HEPIALIDAE. The specimen examined by the writer had 31 segments, but it is not improbable that there may be individual variation.

* Specimens kindly sent to me by Mr. Keppel Barnard were determined as *corvifera*, Meyr., but I failed to find the fringe of projecting hair-scales on the under surface of the anterior legs, the character which distinguishes *Metatheora*, to which genus *corvifera* belongs, from *Prototheora*. The specimens, however, were in alcohol, and it is quite possible that the scales had become detached.

The Legs.

The only character which need be taken notice of is furnished by the tibial spurs. Here *Anomoses* agrees with the Prototheoridae in having one pair on the middle tibia and two on the hind tibia; in no Hepialid, as far as I am aware, are tibial spurs present.

The Wing Venation.

Dr. Turner (1927) has recently figured the venation of *Anomoses*, and with his findings the writer agrees in all essential particulars. As Dr. Turner points out, the upper part of the Media (M 1 + 2) is absent in the fore-wing and but slightly developed in the hind-wing. The former course of M1 + 2 is, however, fairly clearly indicated in the fore-wing, *mf'* being placed a little basad of the middle of the cell. In the specimen examined by me, R4 and R5 were only approximated basally, but in Dr. Turner's series these veins were found to be either approximated, connate or short-stalked. In the Prototheoridae R4 and R5 are well stalked in both fore- and hind-wings; in the Hepialidae these veins are usually free, though short-stalked in the fore-wing of *Oncopera* and in both wings in *Hectomanes*. In the male of *Anomoses* there is, on the dorsum of the hind-wing, a fold containing a pencil of long hairs (figs. 9 and 10). On flattening out this fold I was unable to detect any vein in the area, but it is probable that in the female an anal vein is present, as figured by Dr. Turner (1927).

Summary and Conclusions.

On a consideration of the above data, together with a study of the figures, it will be seen that there are only three really important points bearing on the systematic position of *Anomoses*, viz., the character of Sc, the tibial spurs and the antennae. It is true that the male genitalia exhibit considerable differences between the three groups, the Prototheoridae showing the extreme of variation. To the writer, however, it seems that while the characters of the male genitalia are of the highest value for the determination of species, they must be used with the greatest caution in connection with any higher grouping. Recent studies of the male genitalia of the New Zealand Tineidae and Lyonetiidae exemplify this (see *Trans. N.Z. Inst.*, vols. 58 and 59). The three important characters referred to may be tabulated thus:—

	Hepialidae.	Prototheoridae.	*Anomoses.*
Condition of Sc.	Unbranched.	Branched in fore-wing and in some species in hind-wing also.	Branched in fore-wing.
Tibial spurs.	Absent.	0—2—4.	0—2—4.
Antennae.	Segments angular; dentate or bipectinate.	Segments simple; pubescent.	Segments simple; pubescent.

It thus appears that while the Hepialidae are well differentiated from the other two groups, there is no important character separating these two from each other. I can only come to the conclusion, therefore, that *Anomoses* does not constitute a separate family, or even subfamily, but must be placed as a genus of the Prototheoridae. If, as was at first supposed, the Proto-

THEORIDAE had been possessed of mandibles, then there would have been justification for the family separation of *Anomoses*, but with that character not substantiated the need for family rank disappears.

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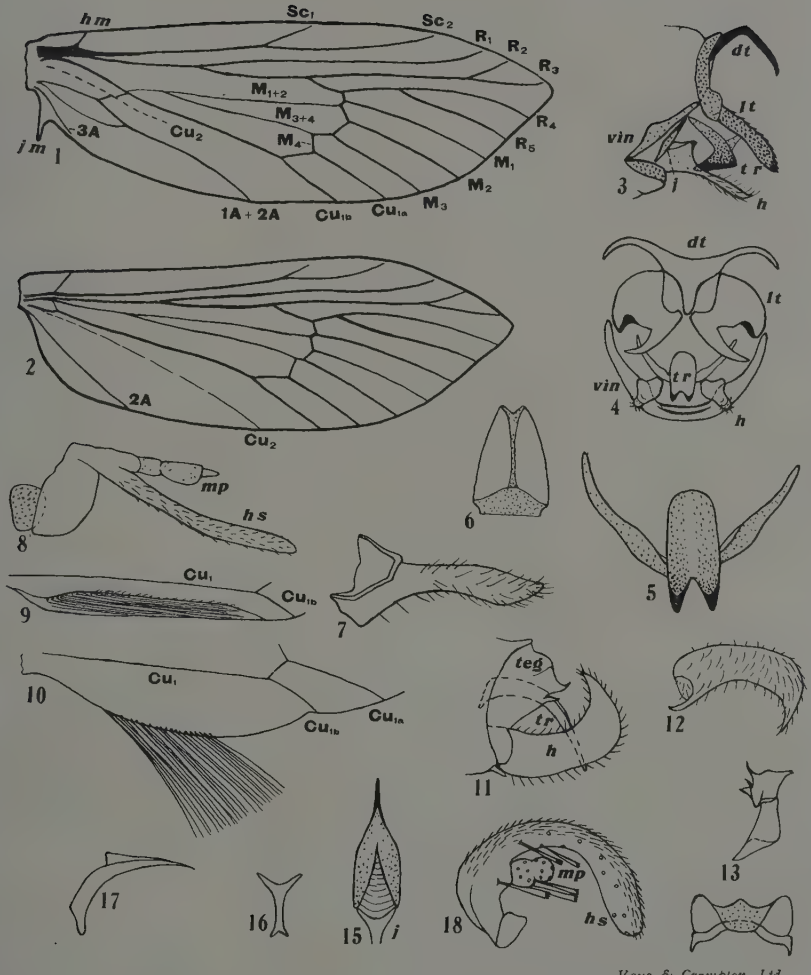
EXPLANATION OF PLATE VI.

(Lettering: 1A to 3A, anal veins; Cu1, first Cubitus; Cu1a and Cu1b, branches of first Cubitus; Cu2, second Cubitus; dt, dorsal piece of tegumen; f, fold on dorsum of hind-wing; h, harpe; hm, humeral vein; hs, haustellum; j, juxta; jm, jugum; lt, lateral piece of tegumen; M1 to M4, branches of Media; mp, maxillary palpus; R1 to R4, branches of Radius; Sc1, first branch of Subcosta; Sc2, second branch of Subcosta; teg, tegumen; tr, trulleum; vin, vinculum.)

FIG. 1. *Metatheora corvifera*, Meyr., fore-wing.
2. ,, ,, ,, hind-wing.
3. ,, ,, ,, male genitalia, lateral view.
4. ,, ,, ,, male genitalia, caudal view.
5. ,, ,, ,, trulleum, caudal view.
6. ,, ,, ,, juxta.
7. ,, ,, ,, harpe, inner view.
8. ,, ,, ,, maxilla.
9. *Anomoses hylecoetes*, Turn., dorsal area of hind-wing with fold closed.
10. ,, ,, ,, dorsal area of hind-wing with fold opened.
11. ,, ,, ,, male genitalia, lateral view.
12. ,, ,, ,, harpe, inner view.
13. ,, ,, ,, left half of tegumen.
14. ,, ,, ,, vinculum.
15. ,, ,, ,, trulleum, dorsal view.
16. ,, ,, ,, juxta.
17. ,, ,, ,, trulleum, lateral view.
18. ,, ,, ,, maxilla.



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THE SYSTEMATIC POSITION OF *ANOMOSES*.

ON THE ABDOMINAL GLANDS IN CERTAIN NORTH AMERICAN ARGYNNIDS (LEP. NYMPHALIDAE)

By H. Eltringham, M.A., D.Sc., F.Z.S.

[Read March 21st, 1928.]

Plate VII.

Some time ago, my correspondent Mr. Austin H. Clark of the Smithsonian Institute, Washington, called my attention to the fact that females of some of the North American Nymphalidae possess, on the upper hind part of the abdomen, certain extrusible glands which resemble in many respects those which Müller described many years ago in Heliconius, and of which I described and figured the structure in our *Transactions*.*

It will be recalled that in females of the genera *Heliconius*, *Eueides*, *Colaenis*, and *Dione* the extrusible glands occur dorsally between the last and penultimate segments, and that there also exists on each side a peculiar organ which Müller named the "stink-club," this organ acting as a special outlet and distributor of the glandular secretion. In the males there is no similar gland in this position, but within the claspers, and communicating with the exterior by a special orifice, there is a large and elaborate gland, differing in structure from that of the females, though producing, so far as the evidence of observers records, a somewhat similar odour. In the above-mentioned genera the secretion of both the male and female glands has hitherto been regarded as offensive to the insects' enemies. The late Dr. C. L. Withycombe described the odour as resembling that of phenyl-carbylamine, though the extract of the glands seems to break down later into other substances (see *Proc. Ent. Soc. Lond.*, 1926, p. 20), one of which has the odour of extract of Witch-Hazel, and later still another smelling like Sweetbriar. So far I have not received anything like such detailed accounts of the sensations produced by the secretions of the Argynnid glands. From the material kindly sent me by Mr. Clark I have, however, been able to make preparations showing the structure of the corresponding glands in this genus. The species available were *A. cybele*, Fab., and *A. idalia*, Drury. Some of the examples received had been preserved under pressure, small pieces of thin wood having been placed on the sides of the abdomen, and then bound with cotton. This treatment had the effect of everting the gland, and of causing it to assume a form and position probably similar to those resulting from its natural extrusion. Plate VII, fig. 1, shows the appearance of the gland of *idalia* when thus treated. I am inclined to think, however, that the artificial pressure applied to the material was considerably in excess of that employed by the insect in life, since on examining sections I found that ovarian tubes had been forced into the interior of the glands. Comparison between figs. 1 and 2 seems to demonstrate that there is a specific difference in shape between the glands of *idalia* and *cybele*. This outward difference, however, does not extend to the internal histological structure, which is the same in both species. Fig. 3 shows the appearance of the gland in its normal position of retraction. It is then quite invisible externally, and can

* *Trans. Ent. Soc. Lond.*, 1925, p. 269; 1926, p. 263.

only be disclosed by the removal of the sixth tergite. After thus exposing it and dissecting away fat and other extraneous tissue, we see distinctly the four muscles shown in fig. 3, which are doubtless used as retractors to withdraw the gland after it has been exserted by internal fluid pressure. When extruded, the organ is turned almost completely inside out in much the same way as are the brush bags in the male Danaine butterflies.* If the gland as seen in fig. 3 be removed, and sections made, we find a structure seen in fig. 4, which shows a small part of the section under a 12 mm. objective. *Ch* points to part of the thin chitinous cuticle of the organ, and the surface bearing the small thorn-like projections, *P*, also forms the external surface of the extruded gland. Thus the space marked *I* in the retracted gland often contains small particles of an extraneous character, such as pollen grains, etc., as well as matter which we may suppose to be the coagulated secretion of the gland. The true internal surface of the cuticle is lined with gland-cells, *Gc*, mainly disposed in a single layer, but, in consequence of the folds, appearing to be more numerous in certain areas. The granular substance seen in some of the interspaces is due to coagulated blood. The gland-cells themselves present no remarkable features. They are not elaborately formed unicellular glands such as may be found in the lateral abdominal organs of *Eryphanis polyxena*,† but appear to be slightly modified hypoderm cells, with a granular cytoplasm and a not very sharply defined nucleus. The chitinous membrane of the gland does not show any definite pores. It is laminated, and in some areas has a somewhat spongy appearance. As in many similar structures, it is probably permeable by the glandular secretion. There are no special organs such as the stink-clubs of *Heliconius*. In the males of *Heliconius* and allied genera there are large and elaborate glands in the interior of the claspers. These were figured and described in the papers already referred to. On dissecting the clasper of the male *Argynnis idalia*, I found an apparently homologous but much simpler structure. Removed from the hard chitin of the armature it has the appearance of a small flattened bladder with a lateral opening communicating with a deep slot on the inner side of the clasper. The bladder may, in fact, be regarded as an invagination of the harpal cuticle, and may even be extrusible by evagination. Mr. Austin Clark ‡ refers to a single unpaired organ situated between the upper ends of the terminal valves, which may possibly be these two organs pressed together. The membrane of these intra-harpal organs is smooth, devoid of pointed projections, slightly laminated, and lined on the inner surface with a layer of cells which in section have the structure shown in fig. 5. These cells and their nuclei are more rounded, and contain more vacuoles, than those of the female gland. Fig. 6 is a surface view of a small piece of the membrane spread flat on a slide; this is traversed by a trachea, on either side of which the gland-cells appear as a kind of mosaic. A peculiar feature, not easily seen in section, is the series of rounded granules arranged more or less regularly round the large nuclei. The cells are not so highly differentiated as those in the corresponding structure in the male *Heliconius*, which have a conspicuous poriferous border.

During the past summer (1927) I endeavoured to obtain living examples of some of our large Argynnids in order to ascertain whether similar organs are to be found in them, but owing to the exceptionally bad season the necessary material could not be secured. For such investigations as these dried specimens

* See *Trans. Ent. Soc. Lond.*, 1913, p. 399; 1915, p. 152.
† *Ibid.*, 1926, p. 367.
‡ "Fragrant Butterflies," *Smithsonian Report*, 1926, Washington, p. 432.

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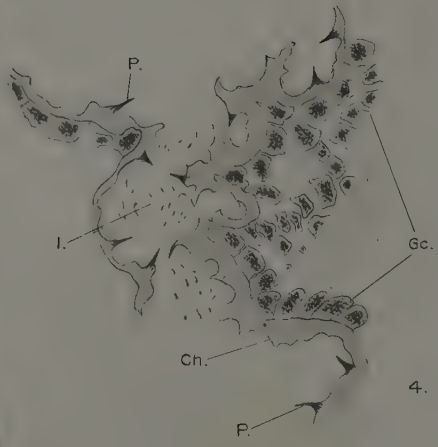

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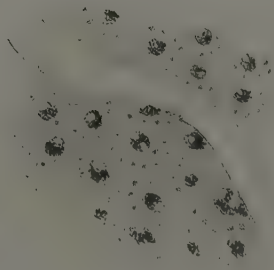

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ABDOMINAL GLANDS IN ARGYNNIS.

are useless, since in a shrunken and desiccated condition the tissues cannot satisfactorily be distinguished. As regards the use of the glands in *Argynnis*, Mr. Austin Clark records* that in the females they give off "a powerful nauseating odour recalling that of the osmateria of the caterpillars of *Papilio polyxenes*." We may therefore regard the secretion of the glands as repulsive. They occur in the same positions and are of approximately the same character as in the probably very closely allied genera *Heliconius*, *Eueides*, *Dione* and *Colaenis*. It would scarcely be safe, however, to regard these organs as any decisive proof of affinity. Several curious examples of parallel development are now known, perhaps the most remarkable of all being the presence of silk-glands and spinnerets in the basal fore-tarsal joints of the Dipterous genus *Hilara*, and of Embiids,† insects of widely separate orders. I am endeavouring to obtain further information on the odour produced by these organs in *Argynnis*. Meanwhile it would add to our knowledge of the subject if others would look for similar glands in our own Fritillaries, and endeavour by observation in the field to throw light upon their functions.

Explanation of Plate VII.

Fig. 1. Enlarged dorsal view of the abdominal gland of *Argynnis idalia* ♀, in its extruded condition.

2. A similar representation of the gland of *A. cybele*.

3. Terminal portion of the abdomen of *A. idalia* with tergites and some of the surrounding tissues removed, showing the gland in its retracted state, with the retractor muscles.

4. Section of part of the retracted gland of *idalia*, as seen under a 12 mm. objective. *I*, the interior, which, on eversion, becomes the external exposed surface. Small particles are seen in the section, partly extraneous matter, and partly coagulated secretion. *P*, one of the pointed spine-like projections, of which many are found on the cuticle. *Ch*, the cuticle of the gland, *Gc*, the gland-cells between which the granular coagulation of the blood is seen.

5. Section of small part of the harpal gland of *idalia* ♂, showing the gland-cells attached to the cuticle. (4 mm. objective.)

6. Surface view of part of the membrane of the harpal gland of *idalia* ♂. The membrane is traversed by a trachea on each side of which is seen the cell-mosaic. (4 mm. objective.)

* *l.c.* and *Psyche*, 1926, xxxiii, No. 1, Notes on the odours of some New England Butterflies.

† Eltringham and Hamm, *Proc. Royal Soc.*, 1925, B., Vol. 102, p. 327.

TWO JAPANESE AQUATIC GLOWWORMS

By Yô K. Okada, Naba, Hyogo-ken (Japan).

(Communicated by K. G. Blair, B.Sc.)

[Read March 21st, 1928.]

Plate VIII and Six Text-figures.

The "Aquatic Glowworm" will probably be of interest to European naturalists because, as far as I am aware, no such insects are found in Europe. All previous records are Asiatic. One species was found in some numbers in the Malay States beneath the surface of small stagnant pools (Annandale, N., 1900, p. 862). Another aquatic larva belonging to the same family was subsequently found by Annandale (1906, p. 106) to be not uncommon in Calcutta (India) among the roots of a floating water-plant. This larva is considered to be that of some common fire-fly, possibly *Luciola vespertina*, Fabricius. A third larva forms the subject of Blair's recent notes (1927, p. 59; 1927*a*, p. 43) and was collected in a mountain stream in S. Celebes at an elevation of about 4000 feet. Blair suggests that his larva may be that of *Pyrophanes similis*, E. Olivier, the adult of which has been already described from Celebes.

In Japan we have at least two kinds of aquatic glowworms, one (fig. 1*a*) large in build, which lives in streams of clear water, and the other (fig. 1*b*) much smaller than the first, and common in the rice-fields, the bottoms of which are muddy and the water always more or less turbid. Both glowworms can easily be collected during warm cloudy nights in late April and can be reared to the adult.

From the outset of the culture experiments it was supposed that the worms ate water snails or gastropods, since the terrestrial larvae feed upon land molluscs. In captivity they actually ate *Limnaea* and *Planorbis*, and the grown-up larvae were found to be very fond of *Melania* and *Oncomelania*.

The larvae in captivity crawl underneath stones or hide among the roots of grasses put into the insectary, and are only active during the night. Feeding also takes place during the hours of darkness.

At birth the glowworms are only a millimeter long, but at the time of pupation the smaller form is rather longer than 1 cm. and the larger 3 to 3·5 cm. From birth to pupation there are, however, no special changes in shape, colour or even structure of the body; the larvae grow gradually in size. As these larvae in nature hatch in midsummer and become adult in the early part of the next summer they probably have a long winter sleep, but in the insectary they were active the whole year round.

In appearance the Japanese larvae (fig. 1) are very like those from Celebes (comp. Blair's figure) though differing in the colour of the dorsal chitinous plates. The body is elongate and has a narrow anterior end. The head, which is small, as is usual in the larvae of this family, is retracted at rest into the prothorax. The posterior end bears a brush-like tail-apparatus (fig. 6). Between the head and the tail-brush the body is distinctly divided into twelve segments, the dorsal surface of each segment being protected by a pair of chitinous

plates placed one each side of the middle line. The prothoracic (fig. 2 (1)) and last abdominal segment (fig. 2 (4)) each have, however, only one plate. There is no indication whatever in this case that the single plate is due to a fusion of paired plates similar to those of the other segments. The prothoracic plate is larger than any other plate and bears a characteristic pattern. The pattern of the meso- and meta-thoracic and abdominal plates is subject to variation (according to the environment), but that of the prothorax is quite constant in

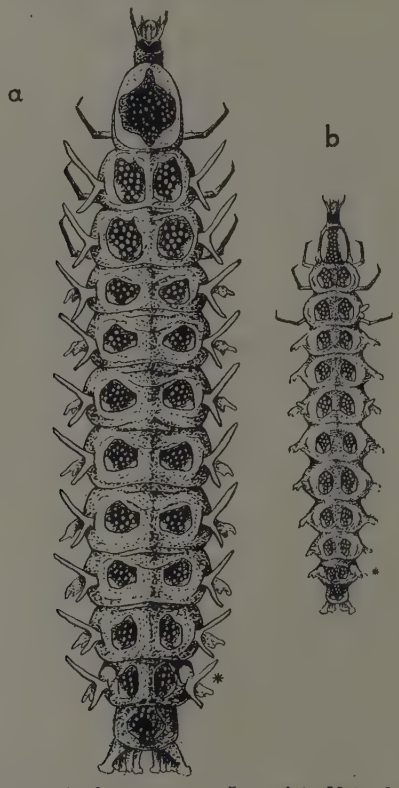

Fig. 1.—Japanese aquatic glowworms. *a*, *L. cruciata*, Mot.; *b*, *L. lateralis*, Mot.

each species. In the smaller form the plate has a wide median black line with a yellowish area on each side of it (fig. 2 (1)), while in the larger form the middle black area is cross-shaped, the transverse bar being particularly broad (fig. 1*a* and Pl. VIII E). This specific difference of the prothoracic pattern is present not only in the larval stage, but even after the metamorphosis.

Awakened from their long sleep by the warm light of mid-April, the glow-worms leave their winter quarters and wander about in search of prey. Their movements can be followed in the dark by a blue glow-light which they emit from the posterior parts of their bodies. This light is localised in the pen-

ultimate segment, but these larvae differ from all those previously described in that the light-producing organ on each side of this segment is situated dorsally and not ventrally (see fig. 3, *ph*).

The larvae attain their full size a little before pupation. Although they have adopted an aquatic life, they have not forgotten the terrestrial habits of their ancestors. A suitable spot on the surface of the ground—usually at the base of grasses—is chosen, and they at once begin to build over themselves a lattice work of soft earth in the shape of a small dome, and by these means they conceal themselves in about two days. In the construction of this cell the larvae remove earth from underneath themselves by means of their mandibles.

Fig. 2.—Dorsal plates of *L. lateralis*, Mot. 1, prothorax; 2, mesothorax; 3, penultimate or 8th; 4, last or 9th abdominal segment.

The method of building the earth chamber is so similar to that which has been described by Hess (1920) in the larvae of *Photuris pensylvanica*, De Geer, that it does not seem necessary to repeat the description here.

By the time the pupal-cell is constructed, the larva becomes sluggish and its body distended. In two or three days the cuticula splits down the middle of the thoracic tergites, and a soft cream-coloured pupa gradually comes forth. From this time onwards, as has been mentioned by Hess, the glowworm lies on its back within its earth-cell (Pl. VIII G), but the aquatic larva develops no supporting setae (Pl. VIII C and D), which are said in the terrestrial larva to project from each of the thoracic and abdominal tergites. The pupa is able to move. This is the stage when the most beautiful luminescence is observed. The light comes from the abdomen, thorax and even from the head. The

same observation has already been made by Watasé (1902, p. 65) in the same aquatic larvae.

After about three weeks of underground life the glowworm again moults, and the perfect insect then comes out on to the surface of the ground. The beetle in each case proved to be one of the common Japanese fire-flies, *i.e.* from the larger larva comes forth *Luciola cruciata*, Motschulsky, and from the smaller *Luciola lateralis*, Motschulsky. *Luciola cruciata*, Mot., bears the Japanese name "Genji-botaru" * and has the synonym *L. picticollis*, Kiesenwetter. *Luciola lateralis*, Mot., is called by the Japanese "Heiké-botaru" * and is synonymous with *L. vitticollis*, Kiesenwetter. *L. parvula*, Kiesenwetter is sometimes considered to be the same species, but the fire-fly which should bear this name is in reality a distinct species, differing not only in mark-

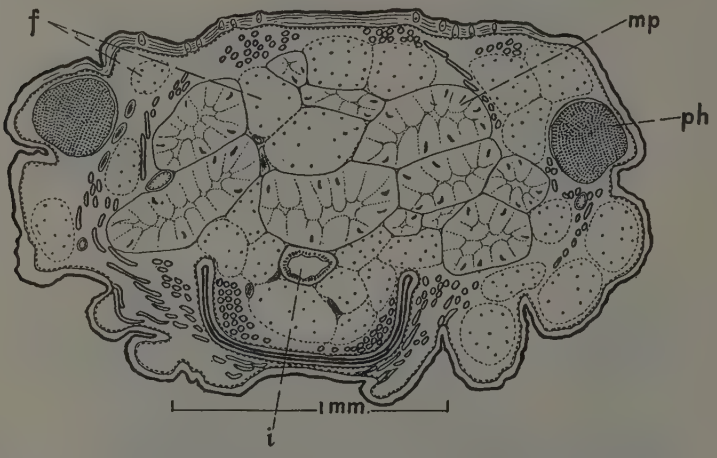

Fig. 3.—Transverse section of the penultimate segment bearing light organs. *f*, fat body; *i*, intestine; *mp*, malpighian tubule; *ph*, light organ.

ings, but also in the shape and puncturation of the prothorax and in the form of the luminous organ of the male.

Special Remarks.

1. *Gill.* Since the glowworms are perfectly aquatic and never come up to the surface even during the night, only air dissolved in water is available for them. Respiration by means of gills of various forms is found in different groups of aquatic insect-larvae. In the present case, a row of slender epidermal processes projects from each side of each of the abdominal segments (the last segment has no gills). Each process (fig. 4) is a hone-shaped, sack-like organ, and contains branches of tracheae. It also bears a few "respiratory hairs."

2. *Defensive Organ.* The larvae of *Luciola* are provided on each side with

* "Genji" and "Heiké" are family names of Shogunate in old Japan, standing one against the other. The first family is symbolised by a white flag and the second by a red. "Hotaru" means fire-fly, and this word, when connected with other words, is pronounced as "Botaru."

a row of peculiar forked organs which project outwards further than the gills. In addition to those on the abdomen, there is a pair of the same organs on each of the meta- and meso-thoracic segments. They are bifid epidermal processes, with the anterior branch longer than the posterior (see fig. 1). At rest they are hidden, being retracted into the body. But when the larvae are irritated the organs are protruded each from a slit-like crevice situated a little way above the gill, and at the same time a peculiar odour is perceived, which Prof. Watasé compares to a mixture of resin and peppermint. He is of the opinion that the forked organs form a defensive apparatus.

3. *Mouth Parts.* When the minute head is retracted within the prothorax the mandibles alone are visible. Each of them (fig. 5 *md*) is a hook, strongly curved inwards, sharply pointed and with a canal running through its entire length. The mandibles of the aquatic larvae are symmetrical, the right being a mirror image of the left. They have no secondary tooth. Excepting the distal end they are densely covered with hair, and the hairs on the inner surface

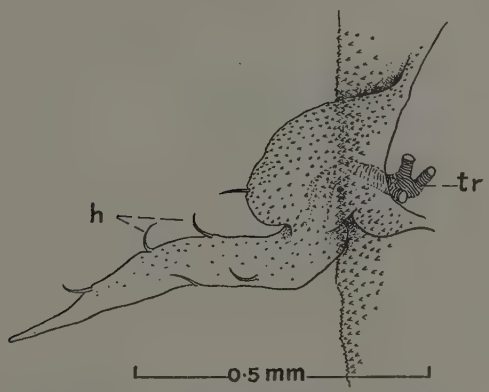

Fig. 4.—Gill. *h*, respiratory hair; *tr*, trachea.

are thicker than usual and regularly arranged. There is immediately behind the orifice of the canal a bunch of several long hairs. There are also some differences in the other appendages from those of the terrestrial larvae, but the principal structure of them is the same. Fig. 5 represents the head of the smaller larva (*L. lateralis*, Mot.), viewed from the dorsal side, and it will show at once how closely it resembles the head of other larvae of the same family : *Lampyris* (Haddon K., 1915, p. 79, Pl. 1; Vogel, R., 1915, p. 345, figs, 21–28); *Phausis* (Bugnion E., 1922, p. 1, figs. 1 and 2); *Photuris* (Hess, W. N., 1920, p. 39, figs. 10 and 11), for example.

The lacinia (*lobus internus* after Vogel) of the maxilla attains in this case an enormous development, and the galea (*lobus exterus*) lies upon the palp. The larvae in question suck half-digested snail broth as the terrestrial larva do, the digestive fluid being brought out through the mandibular canal and injected into the prey. The strong development of the inner branch of the maxilla will probably prevent the entrance of an excess of water into the pharynx at the time of feeding. The suction seems to be due to the muscular action of the pharyngeal part.

4. *Economic Value of the Larvae.* The aquatic glowworms are very greedy

and gluttonous. Once they have seized a snail they will never leave it. They can kill a snail several times as large as themselves. They hold their prey by the strong mandibles, and by day and night continuously suck its juice. Light

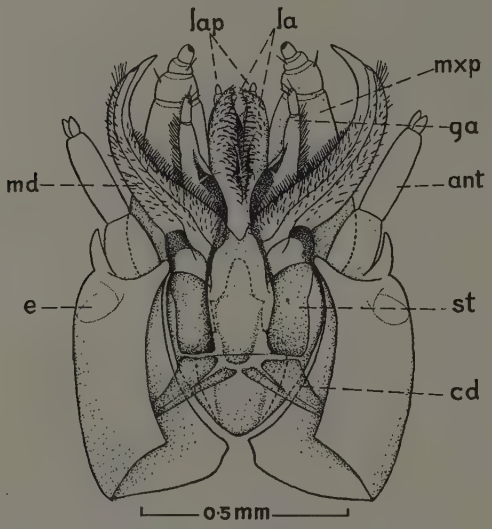

Fig. 5.—Larval head of *L. lateralis*, Mot. (dorsal view). *ant*, antenna; *cd*, cardo; *e*, eye; *ga*, galea; *la*, lacinia; *lap*, labial palp; *md*, mandible; *mxp*, maxillary palp; *st*, stipes.

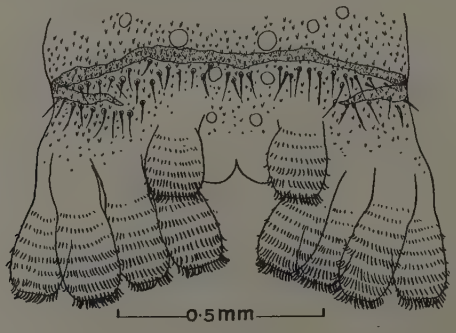

Fig. 6.—Tail organ.

of any kind they detest, but when once they have taken possession of their prey the light of daybreak no longer seems to affect them. Very often we have observed in nature a larva pushing its anterior part into the shell of a water-snail. Perhaps based upon such an observation is the Japanese legend which tells that "fire-flies come from *Melania*," a small fresh-water gastropod abundant in streams. We should not fail to notice this fact.

In certain districts of Japan the epidemics caused by such Distoma as *Schistosomum japonicum*, Katsurada, *Paragonimus ringeri*, Cobbold, and *Metagonimus yokogawai*, Katsurada, are quite serious. The *Schistosomum* has been found to have its intermediate host in *Oncomelania* and the other two lung Distoma in *Melania*. In Japan also the larvae of *Fasciola buski*, Lankester, have been discovered in *Planorbis* and *Segmentina*, and those of *Clonorchis sinensis*, Cobbold, in *Bythinia* and *Melania*. As the culture experiments show, the aquatic glowworms eat these water-snails and gastropods. The discovery of intermediate hosts of the above Distoma in the mollusca, and the fact that the aquatic larvae of *Luciola* live upon some of the latter, may give some hint as to methods of destruction of the epidemics. Dr. Miyajima has already noticed this point, and has written an interesting article, "Protect Fire-flies," in a popular magazine. But it is to be regretted that his warning has not caused any practical attempts to be made either to rear the glowworms or to protect the fire-flies. On the contrary, fire-flies are diminishing year by year in Japan. One of the causes is that in that country fire-flies are objects of traditional pleasure to careless people, who, in the evenings of early summer, kill a great number of the luminous insects.

Finally, I wish to express my sincere gratitude to my old master, Prof. S. Watasé, by whose favour I can here reproduce the beautiful sketches of different stages of *Luciola cruciata*, Mot., and to my friend, Prof. T. Komai of the Kyoto Imperial University, who copied for me some lines of Dr. Miyajima's article in *The Taiyo* and has sent me some specimens of the smaller type of glowworm from which are prepared most of the figures in the text. My thanks are also due to Mr. K. G. Blair of the British Museum for his kindness in sending reprints of his paper at my request, and to Dr. R. Dollfus of the Paris Museum for the indication of the intermediate hosts of Japanese Distoma in molluscs.

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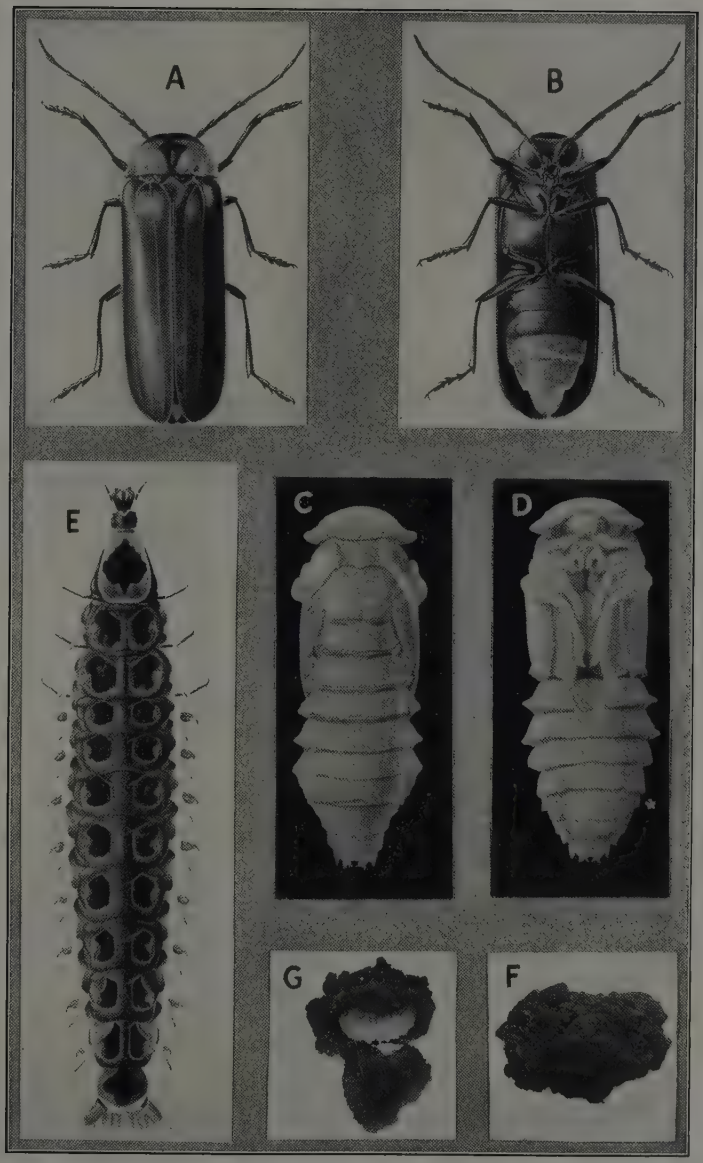
Explanation of Plate VIII

Luciola cruciata, Mot.

A, dorsal, and B, ventral, view of the adult ♂.
C, dorsal, and D, ventral, view of the pupa.
E, dorsal view of the larva.
F, pupal cell. G, the same opened.



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LUCIOLA CRUCIATA, MOT.

NOTES ON THE *ODONATA* OF YUNNAN, WITH DESCRIPTIONS OF NEW SPECIES

By Kenneth J. Morton.

[Read March 21st, 1928.]

With Seven Text-figures.

Some months ago I had the pleasure of receiving from Mr. George Forrest a collection of *Odonata* gathered by him on his last expedition to North-west Yunnan, and I take this opportunity of thanking him for his generous kindness in handing over to me this exceptionally interesting material. Absence from home has prevented me from dealing with it sooner.

Mr. Forrest's experience of the wonderful valleys of this region is unequalled, the results of visits extending over many years, and, as is well known, his researches in its marvellous flora have been of the very first importance as contributions to the knowledge of the flora of Eastern Asia, while he has enriched our gardens with many beautiful and interesting plants. If, however, the quest for botanical material has been the main object of his journeys, he has not neglected zoological subjects. Of these he has made valuable collections, including many insects, of which the dragonflies now to be noticed form a part. These are all from the Mekong valley between 26° and 29° N. lat. and westward towards the Mekong–Salween divide. As he tells me that he has been asked to undertake another expedition to North-west Yunnan and South-east Tibet, it is reasonable to hope that the following is not the last word on his captures of *Odonata* in this very strange land.

Little has been written on the dragonflies of Yunnan, the neighbouring province of Szechuen and South-eastern Tibet. In the *Ann. and Mag. Nat. Hist.*, Series 6, Vol. 13 (1894), and Series 6, Vol. 17 (1896), McLachlan published two papers entitled, respectively, "On Two Small Collections of *Neuroptera* from Ta-chien-lu in the Province of Szechuen" and "*Odonata* from the Province of Szechuen in Western China and Moupin in Eastern Tibet." More recently Lt.-Col. F. C. Fraser, in the *Journal and Proceedings of the Asiatic Society of Bengal* (New Series, Vol. 19, 1923, No. 9), gave an important paper on the *Odonata* collected by the Percy Sladen Trust Expedition to Yunnan under the leadership of Professor J. W. Gregory, in which seven new species are described. The localities mentioned by Fraser may be identified by reference to Gregory's book, *To the Alps of Chinese Tibet*.

The present collection includes at least two new species, one of which it gives me pleasure to name after the collector, while a third, represented by a single female, is probably also new. Several other species are additions to the Yunnan list, including the little-known *Mesopodagrion tibetanum*, McLach., and remarks are made on some of the species which were found by Gregory, but which were not in a satisfactory condition in his collections, many of his specimens having become badly macerated in the poor spirit in which they had been placed.

A description is given of the ♂ of *Temnogomphus M-flavum* (Selys) from North China, as it is closely allied to a Yunnan species and was previously known from the female only.

Calopteryx oberthüri, McLach.

2 ♂♂, adult, in fine condition, agree perfectly with McLachlan's description. The basal space is entirely free and the venation more open than in *Matrona*.

Fraser referred 3 ♂♂, 1 ♀, taken by Gregory, to McLachlan's species, but considered them as belonging to *Matrona*, in which genus the basal space is crossed and broken up into irregular cellules. Fraser's figure (*l.c.*, p. 456) unfortunately does not show the venation of the dark portion of the wings. The colour scheme, however, is the same as in my examples of *C. oberthüri*. It is difficult to accept the view that McLachlan confused two conspicuously different genera, and it seems safe to assume that if Gregory's examples belong to *Matrona*, they cannot be the same species as that described by McLachlan, the present location of whose types, according to Fraser, is not known.

Mnais gregoryi, Fraser.

2 ♂♂ subjuv., and 5 adult. No doubt on account of the condition of the type specimens, Fraser's description hardly does full justice to this beautiful species. The whole apical part of the wings beyond the dark zone is of a sub-opaque pure waxy white, in which the dark neuration and somewhat reddish pterostigma stand out. The post-pterostigmatic cells are variable, ranging from a single row, with or without a few Y-shaped cells, to a fairly complete double row. The size also varies. Length of hind-wing, 35–40 mm.

Forrest's collection includes 5 ♀♀ of a *Mnais* which may be associated provisionally with *M. gregoryi*. I do not think it can be the ♀ of the next species. The possibility of the existence of a third species in the region is not excluded.

♀. Head metallic-green, brilliant on labrum, becoming more matt on the rest of the upper surface; labium black; base of mandibles and apex of 1st joint of antennae whitish-yellow. Thorax metallic-green, tending to bronze-green; the dorsal carina and sutures very narrowly black; metepimeron and about the base of the legs whitish-yellow. Legs black, slightly pruinose, femora very dark bronze-green. Abdomen: two basal segments metallic-green, the others bronze-green or slightly cupreous; ventrally slightly pruinose; appendages black. Wings amber-coloured, slightly darker along anterior margin; venation more reddish; pterostigma whitish-yellow. Post-pterostigmatic cells variable as in ♂.

Length of abdomen, 39–40 mm.; hind-wing, 38½–39 mm.

Mnais andersoni, McLach.

2 ♂♂, adult. Length of abdomen, 42–46 mm.; hind-wing, 35½–37 mm.

Thorax metallic-green above, pruinose beneath. Abdomen pruinose on segments 1–3 and 8–10. Wings with a very faint olivaceous tint or almost hyaline, slightly yellowish for a cell or so at the base; venation blackish; pterostigma dull carmine (1½ mm.).

M. andersoni was originally described from two rather small examples from Yunnan (3*mes Addns. Syn. Calopterygines*, 1873). The difference between the descriptions of the two suggests that they represent two species, and Williamson, taking this view (*Proc. U.S. Natl. Mus.*, xxviii, p. 184, 1904), retained the name *andersoni* for the first described, black-veined, example, the other having the wings yellowish-red. Fraser (*l.c.*, p. 458) has described, under the name of *M. maclachlani*, a single ♂ (lacking part of the abdomen—his measurement, 30 mm., appearing to apply to the existing segments only), which he says may possibly be only a local race of *M. andersoni*, differing in

the absence of an olivaceous tint on the wings, their greater length and by the black pterostigma.

Caliphaea confusa, Selys.

Apparently common, represented by a long series of both sexes. On an average smaller than examples in my collection from Sikkim and Assam, for which I am indebted to Lt.-Col. Fraser.

Anisopleura comes, Hagen.

A single ♂. Fraser has recorded another species, *A. furcata*, Selys, from the Mekong Valley, originally described from Burma.

Indolestes coerulea, Fraser.

Length of abdomen, ♂ 29–30 mm., ♀ 29 mm.; hind-wing, ♂ 20 mm., ♀ 21 mm.

♂. Turquoise or greenish-blue with black markings. Head: labium whitish; labrum, genae, base of mandibles greenish-blue, the pale colour continued narrowly to the base of

Fig. 1.—Anal appendages of *Indolestes coerulea*, dorso-lateral view.

Fig. 2.—Same from above. From preparations in Canada balsam.

antennae and narrowly on the lateral ends of post-clypeus; a very fine pale line dividing frons and post-clypeus; labrum finely bordered with black; rest of head dull black.

Prothorax black, greenish-blue on anterior margin and sides and very narrowly on posterior margin; a pale median line, sometimes nearly obsolete, on dorsum.

Thorax greenish-blue, becoming rather paler ventrally, with dull bronzed-black markings; underside pruinose, dorsal carina with a fine greenish-blue line. Black markings as follows: a trilobate dorsal band covering the greater part of mesepisternum; a short line at upper end of humeral suture connected with the dorsal black on mesepisternum; usually three spots near the humeral suture variable in form and another on the mesinfra-episternum; on 1st lateral suture on its dorsal third a fine line, swollen at its end into a rounded dot; a long triangular spot on dorsal fourth of 2nd suture. Post-sternum with obscure lateral lines and two median dots or streaks.

Legs yellowish, rather darker on tibiae and tarsi, femora with black lines.

Abdomen greenish-blue above and brownish beneath, marked with black as follows: dorsal sub-quadrate spot about half length of segment 1, followed on either side by a lateral spot; segment 2 with variable markings—a broad subquadrate basal spot on dorsum and near the apex a dorso-lateral spot ovate or triangular, the extreme apex

narrowly black at the suture; the anterior spot is frequently produced backwards in a long process extending on the carina to between the posterior spots. Segments 3–6 narrowly black at sutures, with small sub-dorsal, sub-basal spots and a larger sub-apical spot narrowly joined on the carina to the black sutures, and its anterior part divided on the dorsal carina; 7–8 black on dorsum with a fine pale line on carina; 7 with a short pale space at the base; 9 blue with a baso-lateral black spot; 10 entirely pale; superior anal appendages pale, black at apex (see Figs. 1 and 2); inferiors about half as long, in profile view sub-conical.

Wings hyaline, hardly tinged, pterostigma nearly black (about 1¼ mm.) over 2 cells; post-nodals fore-wing 11–12; hind-wing 10–11.

♀. Head, prothorax and thorax coloured as in the ♂; abdomen, segment 1 as in ♂, 2 as in ♂, but with tendency to coalescence of the dark markings, the backward process of anterior marking sometimes splitting on the carina, and the resulting branches may meet the posterior spots and merge with them; 3, 4 and 5 as in ♂, but apical spots completely divided on carina and isolated; 6 probably similar, but sub-basal spot not evident; remaining segments probably mostly black on dorsum with a blue line on the carina, but all the examples are more or less discoloured or pruinose. The wings are slightly infumed, more so than in ♂, especially in costal and subcostal areas.

I have a little hesitation in referring these to Fraser's species described from a single ♀. The most important difference seems to be in the form of the anterior marking on the second abdominal segment. Fraser describes this as constricted in the middle and deeply bifid at its apex. The marking, however, shows much variation in the examples before me. In the males there is no indication of the apex being divided, but in the females there is. A constriction such as Fraser figures is not obvious; it may have been individual variation in his single specimen. The markings and form of the ♂ anal appendages recall the species described by Ris from Japan under the name of *Lestes gracilis peregrinus*.

Mesopodagrion tibetanum, McLach.

1 ♂ ad., 2 ♂♂ juv. This little-known species is one of the most interesting in the collection. It was described from a pair from Siao-lou, Szechuen, and Moupin, Eastern Tibet, but I do not know the present location of the types. One of the teneral males has been submitted to Dr. Ris, who agrees with my determination, the only difference of consequence from McLachlan's description being in the length of the pterostigma, which he quotes as 3 mm. in place of 2 mm. in the Yunnan examples. As Ris promises to discuss the species in a paper on the Asiatic *Lestinae* and "Podagrions" generally, in which I hope he may give a photograph of the wings of *Mesopodagrion*, I refrain from entering into further details here.

Calicnemis eximia, Selys.

Apparently common, and represented by a good series of both sexes.

Ceriagrion cerinomelas, Lieftinck.

Tijdschrift v. Ent., LXX, 1927, p. 88.

5 ♂♂ (one defective), 2 ♀♀. This species was recently described from examples from Northern India. One of the Yunnan males has been submitted to Mr. Lieftinck, and he could find no structural differences to separate it from his species, although colour differences exist which may be due at least in part to age or state of preservation of the specimens. The ground-colour

of the thorax is given by Lieftinck as "cinnamon," while in the Yunnan examples it is rather olivaceous-green above, shading into lighter more bluish-green lower down, and passing into pure yellow on the underside, only one example showing a tendency towards brownish above. Variation in the depth of shade gives rise sometimes to vague longitudinal lines. The extent to which the sutures are marked with fine black lines seems to vary. In the Yunnan males almost the whole of abdominal segment 7 is black on the dorsum, while in the Indian ones the black is restricted to the apical half of the segment. In the Yunnan females the segments are black from the 5th or 6th. A ♂ received from Dr. Laidlaw some years ago is, I believe, the same species; it was indicated as from Burma. *Ceriagrion fallax*, Ris, described from a single ♂ from the province of Kwang-Tung, seems also to be closely allied, although in this, according to Ris' figure, the lower anal appendages are longer and not upturned in the same way.

Temnogomphus forresti, n. sp.

♂. Length of abdomen (with appendages) 34 mm.; hind-wing, 32 mm.

Head: labium, middle lobe black, lateral lobes greenish-yellow. Labrum bluish-white, narrowly black on outer and posterior margins. Genae and base of mandibles bluish-white. Ante-clypeus glossy black; post-clypeus bluish-white, narrowly black anteriorly and posteriorly. Frons greenish-yellow with a narrow black line on its lower part in front confluent with the black upper border of the post-clypeus, and a black line above in front of the antennae. The face is thus marked by a succession of alternating pale and black stripes. Vertex black; occiput very slightly curved, black with a black fringe and a small yellow spot behind.

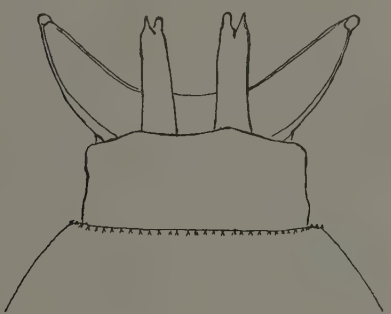


Fig. 3.—Apex of abdomen, with anal appendages, of *Temnogomphus forresti*, seen from above.

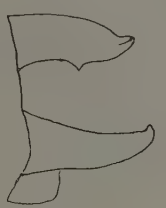


Fig. 4.—Anal appendages of same in profile. From dried specimen.

Prothorax black with a conspicuous greenish-yellow pyriform sub-dorsal spot, and median geminate spot; anterior margin broadly and posterior margin narrowly bordered with yellow.

Thorax, above, black marked with greenish-yellow as follows: an interrupted meso-thoracic collar confluent with oblique antehumeral stripes forming on each side a figure 7, one being reversed; a narrow sinuous humeral stripe almost interrupted towards its upper end, where it is expanded triangularly, and below almost joined to the yellowish base of middle legs. Laterally bright greenish-yellow marked with black, thus: a rather broad humeral stripe (more than half of which is on the mesepimeron and connected with a narrow black line running under the wings to the metepimeron) with a backward knob-like expansion near the base of the wing above, and connected below with the half-length

narrower line on 1st lateral suture, this line reviving more broadly for a short length near the wing-base; a rather narrow distinct line on 2nd lateral suture.

Legs entirely black (pale lines, if they exist on the femora, as is probable, obliterated by age, the specimens being very mature).

Wings hyaline with a very slight smoky tinge, especially at the apex and slightly tinged with yellowish at the base; costa black; pterostigma dark brown over 3–4 cells.

Nodal index $\frac{9–10}{8–8}\left|\frac{12–9}{8–8}\right.\quad\left.\frac{10–14}{12–10}\right|\frac{14–12}{10–11}$.

A basal nervule of 2nd series present in all the wings.

Abdomen as described by Fraser for the genus: two basal segments swollen, then becoming thin and cylindrical to the end of segment 7, thereafter expanding to a maximum width of 4½–5 mm. on segment 8, and again narrowing to the apex, segment 10 being very small. Black with yellowish-green or yellow markings, thus: segment 1 discoloured, probably with a triangular spot; 2 with trilobate mid-dorsal stripe, middle lobe longest; thereafter a thread-like line on dorsal carina to end of 7 interrupted at sutures; apex of 7, 8 and 9 with a very fine yellow line. Laterally, segments 1 and 2, including auricles, broadly greenish-yellow; 3 with basal lateral spot and smaller spots on 4–7; 8 with a very large citron yellow subtriangular spot; 9 with a smaller basal spot; 10 black. Rims of 8 and 9 flanged.

Anal appendages: superiors about the length of segment 10; seen from above, straight, parallel, blackish but apparently paler at the apex, which is bifid, the inner division rounded at the tip, the outer acute and more spine-like. In profile they are on the dorsal side gently and convexly curved to the slightly upturned apex; on the ventral side rather broad at the base, the concave curvature interrupted slightly beyond the middle by a short broad tooth, whence they taper gradually to the apex. Inferior appendage equally long, deeply cleft, the branches widely divaricate, concave above and slightly upturned at the apex (Figs. 3 and 4).

Genitalia of segment 2 very similar to Fraser's fig. of *T. bivittatus* in respect of the horse's head-like hamules; the lobe rather narrower.

Temnogomphus M-flavum, Selys.

Gomphus M-flavum Selys, 4^mes^ Addns. Syn. Gomph., p. 46.

♂. Length of abdomen (with appendages) 37 mm.; hind-wing, 32 mm.

Head: labium, middle lobe black, lateral lobes greenish-yellow. Labrum greenish-yellow with black anterior and posterior margins; anteclypeus, post-clypeus (excepting a small pale dot on either side) black. Frons greenish-yellow with a black anterior line confluent with the black post-clypeus, and a black line in front of the antennae interrupted in the middle; occiput black with black fringe and a rather large spot posteriorly.

Prothorax black with yellow anterior band, pyriform sub-dorsal spots and geminate median spot, yellow; a minute yellow dot on hind-margin probably vestige of a more extended narrow line.

Thorax, above, black marked with yellow as in preceding species; laterally, the narrow black line under the wings turns abruptly down on metepimeron, which it traverses halfway; line on 1st lateral suture short, ending at stigma; knob-like expansion on humeral black less conspicuous but present.

Abdomen shaped as in preceding species; dorsally on segment 1 a triangular yellow spot; trilobate yellow line on segment 2; narrow thread-like line on dorsal carina terminating at end of segment 7 interrupted at sutures; segments 7, 8 and 9 narrowly yellow at apex. Laterally, broadly yellowish on segments 1 and 2, including the auricles; triangular basal spot on 3; small basal spots on 4–7; a large latero-median triangular spot on 7;

a larger one on 8 covering on its lower edge nearly the whole length of the segment; a similar spot on 9 reaching to the proximal side of the flange; 10 all black.

Legs all black.

Wings hyaline with a very slight yellowish suffusion on their basal third. Costa black. Pterostigma dark brown over 3 cells between strong black nervures.

Nodal index $\frac{10–14 \mid 14–9}{11–10 \mid 10–12}$.

A basal antenodal of second series present in all wings.

Anal appendages: superiors very similar to those of the preceding species, black with paler apex; the spine-like branch longer and more slender; in profile view no visible tooth (Figs. 5 and 6).

♀. Length of abdomen (with appendages) $\begin{cases} 38 \text{ mm.}; \text{ hind-wing } \begin{cases} 33\frac{1}{2} \text{ mm., Tatung.} \\ 35 \text{ mm., Chi-feng-hsien.} \end{cases} \\ 40 \text{ mm.}; \end{cases}$

Very similar to ♂. In Tatung ♀, hind margin of prothorax has a longish transverse yellow spot, and the upper end of yellow humeral line is narrowly confluent with antehumeral.

Abdomen: dorsal line on segments 4–7 more strongly marked than in the ♂. Lateral markings more extensive on segments 3–6, the basal spots being larger and triangular,

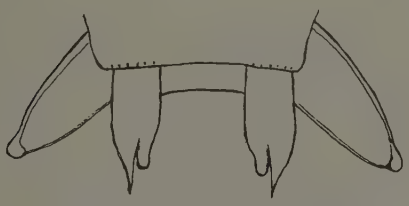


Fig. 5.—Anal appendages of *T. M-flavum* from above.

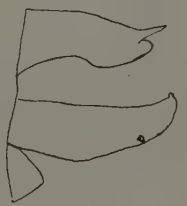


Fig. 6.—Same in profile. From dried specimen.

and each segment has latero-median lanceolate spot; spot on 9 extends to the outer edge of flange. Anal appendages black and acute.

Vulvar scale: 8th ventral segment just before the apex with a ridge gently curved, slightly raised in centre, which is slightly excised with shallow depressions on either side. The margin of the segment shows a median slit (as in Hagen's fig. of *bivittatus*, Monog., pl. 9). The vulvar scale is about half the length of segment 9, narrow, oblong, canaliculate, the margins much thickened, raised, and parallel.

Wings with the yellowish suffusion less extensive. Basal antenodal of 2nd series present in all the wings (double in one wing).

	Tatung.		Chi-feng-hsien.	
Nodal index	$\frac{9–15 \mid 15–11}{11–11 \mid 9–10}$	$\frac{11–17 \mid 16–12}{11–12 \mid 11–12}$	$\frac{12–16 \mid 14–11}{13–10 \mid 10–12}$	

1 ♂, 2 ♀♀ Chi-feng-hsien, Prov. Tschili, North China; 1 ♀ Tatung in same province. The male was not previously known.

Gomphus corniger, n. sp.

♂. Length of abdomen (with appendages), 40 mm.; hind-wing, 36 mm.

Head: labium, middle lobe and proximal part of outer lobes black; rest of outer lobes and the base of mandibles greenish-yellow; face and vertex entirely black, excepting that the frons in front and above is traversed with greenish-yellow. Occiput hardly

elevated, greenish-yellow surrounded by a narrow black margin, and behind black with a pale linear spot.

Prothorax black, with greenish-yellow markings as follows: anterior margin with a line extended caudad in its centre; a geminate spot in the middle with a small dot on either side, and lower down a large yellow spot; a rather broad line on posterior margin.

Thorax black above marked with greenish-yellow thus: complete mesothoracic collar connected with rather broad antehumerals and a fine line on dorsal carina; humerals consisting of an upper spot isolated from a fine line lower down. Laterally, greenish-yellow; an incomplete black line on 1st lateral suture, connected with stigma, which is surrounded by black, and a complete black line on 2nd lateral suture, these lines confluent with black markings on the lower part of thorax.

Legs black; femora of hind-legs extending to middle of 2nd abdominal segment.

Abdomen black: a yellow dorsal band running the whole length to end of segment 9, narrowly interrupted at the sutures; segment 1 crushed; on 2 trilobate; narrow on other segments to 7; slightly broader on 8; broadly triangular on 9; 10 black, apparently without markings. Laterally: a broad yellow band on 1 and 2, including the auricles; large basal triangular spot on 3; small basal spots on 4–7; a large spot on 8, covering

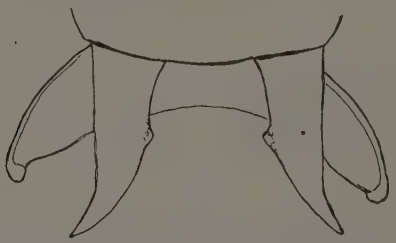


Fig. 7.—Anal appendages of *Gomphus corniger* from above. From dried specimen.

nearly the whole length of segment on its lower margin. Two basal segments swollen, then cylindrical and thin to end of 6, expanding gradually on 7–8, becoming narrower on 9; 10 very small.

Anal appendages black; superiors slightly longer than 10, corniform slightly divergent towards the apex and scarcely upturned; a tooth on their lower inner surface about the middle. Inferior appendage rather shorter, deeply cleft, the widely divaricate branches extending laterally beyond the superiors, tapering and upturned (Fig. 7).

Wings hyaline, slightly infumed; basal antenodal of 2nd series present; triangles and supra-triangles all free; 5 or 6 rows of post-anal cells; 2 cells between M1 and M1a at distal end of pterostigma, increasing to 3 or 4 cells; 3 transverse nervules between M1–3 and M4 in fore-wing, 1 in hind-wing; pterostigma over 4 or 5 cells.

Nodal index $\frac{12–14}{11–9} \Big| \frac{14–12}{10–12}$.

♀. Length of abdomen (with appendages), 43 mm.; hind-wing, 41 mm.

Head and thorax as in the ♂.

Abdomen with dorsal yellow line over whole length, narrowly interrupted at sutures, broad on 1, trilobate on 2, narrow from 3 to 8, broadly triangular on 9, small and more isolated on 10. Laterally broadly yellow on 1 and 2; large basal triangular spot on 3, followed by a line reaching the end of segment; 4 to 7 small basal dot and short median line; 8 with large spot, lower down, more than three-quarters of length of segment, a similar but much smaller spot present on 7; 9 and 10 without lateral markings.

Anal appendages about the length of 10, acute, black, the protuberance between them yellow.

Legs black; spines of posterior femora short and close at the base, rather longer and more widely spaced in distal portion.

Wings as in the ♂; basal antenodal of 2nd series absent, excepting in one fore-wing; 2 nervules only between M1–3 and M4 in fore-wings; 2 rows of cells between M1 and M1a at distal end of pterostigma, increasing at once to 3 cells, then to 4 or 5.

Pterostigma longer, over 5½ cells, dark brown.

Nodal index $\frac{12–17 \mid 16–13}{13–12 \mid 12–12}$.

1 ♂, 2 ♀♀, all rather crushed, but the description should suffice for recognition of the species. It agrees somewhat closely with that given by Fraser of a ♀ "*Heterogomphus* sp." (without name—*l.c.*, p. 454), almost closely enough to suggest the possibility of identity, especially having regard to the bad condition of Fraser's single example. The only rather important discrepancy is in the occipital lamina, which Fraser describes as pointed at the centre. I find no trace of this in the females before me.

Lamellogomphus ?, sp.

♀. Length of abdomen (with appendages), 42 mm.; hind-wing, 39 mm.

Head black, marked with greenish-yellow. Labium middle lobe black, side lobes pale. Base of mandibles, genae, a transverse spot on either side of labium and most of post-clypeus, also frons in front and above (a rather broad black band in front of antennae excepted) all greenish-yellow. Occiput black, slightly notched, yellowish on either side of notch, and behind a yellowish spot.

Prothorax black, marked with greenish-yellow on anterior margin, geminate median spot and a longer yellow spot on posterior margin.

Thorax, above, black with greenish-yellow markings, thus: mesothoracic collar; isolated antehumerals acute below; humerals represented by an upper triangular spot and separate fine line below. Laterally greenish-yellow with complete black lines on 1st and 2nd sutures, connecting above with the humeral black by way of black line under wing bases and below coalescing, the line on 2nd suture broad and extending on both sides of suture, the greenish-yellow between the two sutural lines being reduced to a narrow triangle.

Abdomen black with yellowish markings; segment 1 with dorsal triangular spot; 2 dorsal line fairly broad; 1 and 2 laterally pale; remaining segments, 3 to 9, with rather large latero-dorsal spots, which on 3–4 are followed by lateral linear spots, the anterior spots on 3 reaching the transverse carina and by extending dorsalwards at either end tend to enclose a roughly ovate black area.

Anal appendages about the length of segment 10, acute, black. Vulvar scale small, triangular, cleft.

Legs black. Wings hyaline, hardly tinged. Pterostigma dark brown over 4 cells.

Nodal index $\frac{10–14 \mid 14–10}{11–\ 9 \mid 10–10}$.

Although this example is in good condition, in the absence of the male it is inexpedient to give it a name.

Ophiogomphus ?, sp.

A single female probably appertains to this genus, but, on account of its very teneral condition, it is better to do no more than mention it.

Anotogaster gregoryi, Fraser.

3 ♂♂, 1 ♀. The wings of the males are hyaline, untinged, while in the female they are very faintly tinged with yellowish, more pronounced along the anterior borders. Otherwise the specimens seem to agree with Fraser's species, of which the ♂ came from the Yangtse Valley and the ♀ from a tributary valley of the Mekong.

Gynacantha japonica, Bartenef.

1 ♂, only in moderately good condition, the frons having collapsed obscuring the T spot, and the abdominal markings are discoloured. The identification with *G. japonica*, of which I have a small series, including both sexes, from Japan, is fairly certain. Ris includes *G. japonica* in his list of Formosan species.

Orthetrum japonicum internum, McLach.

1 ♂ adult, 1 ♂ juv., 1 ♀ juv. This species was also taken by Gregory, and McLachlan recorded it from Szechuen.

Orthetrum albistylum speciosum, Uhler.

1 ♂ adult, 1 ♀ sub-juv. The ♂ is in fine condition, and both agree in having in the fore-wings 4 rows of discoidal cells for a longer or shorter space, and in the same way between Rs and Rspl 3 rows as in the larger Japanese examples. Length of hind-wing : ♂, 42 mm., ♀, 39 mm., the former thus agreeing with the greatest measurement given by Ris. Neither McLachlan nor Fraser mentions this species from the region. The latter, however, records *O. cancellatum kraepelini* from badly macerated specimens taken by Gregory; this race is a small one according to the figures given by Ris : hind-wing, ♂ 33–35 mm., ♀, 34 mm. Fraser gives no measurements.

Orthetrum triangulare melania, Selys.

2 ♂♂, adult. Both McLachlan and Fraser record this sub-species, but the two males hardly conform to the typical *melania* as represented by a good series of both sexes in my collection from Japan, in which there are four rows of discoidal cells in the fore-wing and the triangle has two cross-veins and sometimes three. The Yunnan examples have three rows of cells and one cross-vein.

Orthetrum pruinosum neglectum, Rambur.

2 ♂♂, 1 ♀. Already recorded from Yunnan by de Selys.

Sympetrum eroticum ardens, McLach.

A good series of both sexes. The type was from Szechuen.

Sympetrum baccha, Selys.

A single ♀ is referred to this species. Males are desirable for confirmation.

Crocothemis erythraea, Brullé.

Both McLachlan and Fraser refer to *C. servilia*, but the few examples before me from Yunnan are, I believe, *C. erythraea*. Lieftinck (*Tids. v. Ent.*, LXX, 1927, p. 97) in dealing with specimens from Northern India makes some observations on these two species.

Brachydiplax yunnanensis, Fraser.

One ♀, somewhat teneral and crushed, appears to belong to this species.

TWO RARE ALGERIAN HESPERIDAE: *SLOPERIA AHMED* AND *TUTTIA LEUZEAE*

By A. de B. Goodman.

[Read March 21st, 1928.]

With Three Text-figures.

We had the good fortune to take *Sloperia ahmed* and *Tuttia leuzeae* at Teniet-el-Had in the Atlas during the last week in May 1926. Specimens were submitted to Mr. N. D. Riley, who kindly forwarded them on to Mr. B. C. S. Warren. From the dissections made Mr. Warren identified them as stated above.

The following notes are offered as an addendum to Mr. Warren's "Monograph of the Hesperiidi," in *Trans. Ent. Soc.*, Vol. LXXIV, page 165 (Note).

SLOPERIA AHMED, Ob.

Syrichthus ahmed, Ob., Études Lep. Comp. VI, p. 108, Pl. CXL, figs. 1259, 1260.

Identification: *Genitalia* (Fig. 2 (1)).—Uncus long and slender; clasp more or less oval. The harpe increases in breadth in its distal half and slightly decreases at the point where it curves downwards towards the cuiller, and increases again, being blunt at its termination with the latter process. The cuiller extends for half the length of the clasp, terminating in a forked manner, between which rests the termination of the harpe. The lateral apophyses are set very low down, as in *proto*, below the level of the dorsal edge of the clasp.

Text-fig. 1.—*Sloperia ahmed*, Ob., ♂.

The male armature of *ahmed* thus resembles in general structure that of *S. proto*, Esper, and *S. mohammed*, Obthr. (See *Trans. Ent. Soc.*, Vol. LXXIV, Part I, page 149, Pl. LV, fig. 2, page 24, Pl. VIII, fig. 1.)

In the mount of *S. ahmed* figured the right side of the ring of the 9th segment has been accidentally severed.

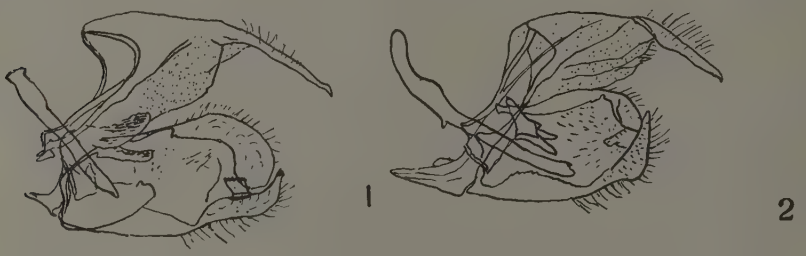
General Features.—See "Monograph of Tribe Hesperiidi," by B. C. S. Warren, page 44.

Size, ♂ 30–33 mm.; ♀ 35 mm.

Upperside: *fore-wings*.—Discoidal series incomplete, discoidal lunule alone present, median row incomplete, 5th and 6th spots wanting, spots 1, 2, 3, 7, 8 and 9 approximately equal in size and more or less square in form. Spot 4 reduced to a dot. Outer row complete set of eight distinct spots. Discal spot very narrow, but sharply defined. Subcostal spots wanting. *Hind-wings*.—One basal spot, the second, present (in one specimen basal spot three also present). Median band complete, consisting of large, approximately square spots. Marginal row present and well defined. Inner half or the wings covered with yellowish hairs, somewhat obscuring light spots.

Underside: *fore-wings*.—Discoidal lunule and first four spots of median band standing out clearly against a dark background, discal spot distinct on its inner edge but merging

into a slight suffusion of whitish scales on its outer edge, the three apical spots of the median row distinct, the outer band complete, but the last four spots surrounded by a whitish suffusion. The basal area and the costa covered with whitish suffusion. *Hind-wings.*—The two basal spots present, much larger than those in *proto*, being the second



Text-fig. 2.—♂ Genitalia, lateral view, of (1) *Sloperia ahmed*, Ob., (2) *Tuttia leuzeae*, Ob.

and third, the latter spot much the larger; median band complete. Marginal row complete and composed of distinct dots. Ground-colour of the underside dark greenish-brown and all white spots intense.

Sexual dimorphism.—Upperside and underside of ♀ more ochreous. The costal fold of the ♂ not always well developed.

Date of Emergence, Flight Period and Habitat.—Two fresh male specimens taken on 28th May, 1926, flying over grassy hillocks covered with thyme patches, behind the cemetery on the hill, to the east of Teniet-el-Had, North Atlas. And on 30th May a worn female specimen taken at the same spot. Altitude 1,160 metres (*O. R. Goodman*). June, Lambessa (*Oberthur*).

TUTTIA LEUZEAE, Ob.

Syrichthus leuzeae, Ob., Études Ent. 1881, p. 60, Pl. III; *id.*, Études Lep. Comp. VI, p. 107, Pl. CXLI, fig. 1275; *Hesperia leuzeae*, Ob., Mabille in Seitz, Macrolep., I, p. 337, pl. 85.

Identification: *Genitalia* (Fig. 2 (2)).—Uncus long and slender; aedoeagus curved; the harpe small and slightly larger in its termination. The cuiller curved, terminating in a sharp point, the height of the cuiller being nearly equal to the breadth of the clasp. There is no terminal tooth developed from the apex of the cuiller as in the other species of the genus. There are two sharp-pointed wing-like processes which spring from the penis sheath.

Text-fig. 3.—*Tuttia leuzeae*, Ob., ♂.

General Features.—*Size*, ♂ 27–30 mm.; ♀ 30 mm.

Upperside: *fore-wings.*—The ground-colour of scales brown tipped sparsely with white; the discoidal series represented by broad discoidal lunule; median row variable, incomplete, usually 1st, 2nd and 5th spots wanting, but in some cases the 5th spot alone absent; the 6th, 7th, 8th, and 9th spots rectangular, and the 3rd and 4th more or less square and the largest of the series. In cases in which the 1st and 2nd median spots are present they are broken, so producing two small spots between them and the outer row, as in *tessellum*. The outer row complete but indistinct; discal spot a line and obsolescent. Subcostal spots wanting. *Hind-wings.*—One basal spot

present; the 2nd median band incomplete, the 1st spot missing and the 7th often obsolescent. Marginal row complete, dots distinct.

Underside: *fore-wings.*—General appearance whitish along the marginal and costal areas, a greyish area in the middle of the wing to the dorsum, upon which the white spots, corresponding to those of the upperside, stand out distinctly. *Hind-wings.*—General appearance white. The white markings corresponding to those of the upperside so extended and suffused that darker greenish areas between the basal and the median band, and the median band and the marginal row, stand out as distinct bands.

Sexual dimorphism.—Upperside ♀ more ochreous than ♂. Underside fore-wings, the greyish areas of ♂ replaced by ochreous in the ♀. The costal fold of the ♂ not always well developed.

Date of Emergence and Habitat.—Thirty-five specimens were taken, of which nine were females (*O. R. Goodman*), viz. :—

28th May, 1926, Teniet-el-Had, altitude 1,166 metres, common and fresh above the Cascade, to the east of the stream;

29th May, 1926, very common, flying in glades and settling on the leaves of large umbelliferous plants in the cedar forests at Teniet-el-Had;

31st May, 1926, a few in the meadows below the Maison Forestiére in the Cedar forests, Teniet-el-Had.

Oberthur records one specimen from Mascara (1881) and later a few from Sebdou.

Note by B. C. S. Warren.

Mr. Goodman very kindly sent me the MS. of the above article to insure that his descriptions corresponded with those given in my monograph. He is to be congratulated on his discovery of further specimens of these two almost unknown species. Thanks to him, I was able to dissect two specimens of *leuzeae* and one of *ahmed*. The two dissections of the former show it to be a very distinct species, belonging to the genus *Tuttia*, but widely separated from any other known species, the highly specialised formation of the cuiller being most distinctive. The case of *ahmed*, however, is less satisfactory. The one dissection shows distinctly that *ahmed* is a member of the genus *Sloperia*, but it leaves one in considerable doubt as to the specific standing of the insect. We already have a similar case in the genus. The ♂ genitalia of *S. proto* and *S. mohammed* are very similar, so much so that Dr. Reverdin questions if they are distinct. He agrees, however, that the details of the early stages of both, which have been noted by Mr. H. Powell, seem to show that they are most correctly dealt with as separate species. One may note that there are slight differences in the genitalia of both, but lack of material prevents one deciding if these differences are constant. Between the genitalia of *ahmed* (as shown by our one dissection) and that of *proto*, I can trace only one distinctive difference, namely, that in *ahmed* the whole structure is larger than in *proto*. This increase in size makes various parts (harpe, lateral apophyses, aedoeagus and uncus) appear different, but exactly how much the difference depends on the increase in size it is hard to say. Until a good number of specimens is available for dissection it will not be possible to determine this point, or even to feel sure that the size of our one specimen is the normal. If this, however, should prove to be so (which is very likely, for such regularly developed enlargement in all parts is, to my knowledge, unknown as a mere variation in other species), it will be a factor of more value than might be

supposed, for *ahmed* is the smaller of the two insects. Further, *proto* varies in size to a considerable extent, and though I have not had any specimens of the very large race from the Atlas Mountains to dissect, I have not found any variation in the size of the genitalia of specimens from Africa, Spain or France. We must hope that Mr. Goodman will at some future date return to Algeria and procure the specimens necessary to supply the wanting data for the settlement of the question he has already done so much to elucidate.

ODONATA OF THE AFRICAN CONTINENT

By Lt.-Col. F. C. Fraser, I.M.S.

[Read March 21st, 1928.]

With Six Text-figures.

The dragonflies of Africa are less known than those of any other of the five continents; with practically the whole of the literature on the subject at my disposal, I have been able to list only some 380 species, a number which falls short of the known Indian fauna by at least 100. When comparing the respective sizes of the two areas concerned, we are compelled to come to the conclusion that a great number of dragonflies yet remain to be discovered in Africa. It is true that India is a particularly rich faunal area so far as the *Odonata* are concerned, and probably the cradle of the Order; it is also true that a very large area of the African continent consists of desert wastes, which are inimical to dragonfly life, yet, in the latter respect, India for its size has also a proportionate amount of arid lands where dragonflies are almost unknown. It is the montane districts of India which furnish such a wealth of material, and it is just such areas that, in Africa, have remained totally unexplored. It was in the hope therefore that a willing band of helpers might be found to work such districts in the dark continent that I sent out an S.O.S. in 1926 asking for Odonate material. In point of the number of letters sent out, the response was poor; most of my letters remained unanswered, a few others elicited replies that, owing to the writers being too fully occupied in working on other orders, they were unable to assist. Only three entomologists in all sent me collections, which have well repaid the trouble taken. Of these, Dr. G. Hale Carpenter collected some seventy species on the shores and in the vicinity of Lake Victoria Uganda, several of which proved to be new to science. Four collections were sent by this enthusiastic naturalist, with a promise of more to come, whilst collections were also received from Messrs. Colin Smee of Zomba, Nyasaland and H. Hargreaves of Uganda, to all of whom my thanks are due.

In this paper, which I hope to be the first of a series dealing with the African dragonfly fauna as a whole, I have described ten new species and completed the descriptions of two others. Figures of the appendages have been given where possible, being camera lucida studies drawn by the author. Types, where not otherwise mentioned, will be deposited in the British Museum.

Order *ODONATA*.

Sub-order *ZYGOPTERA*.

Agriocnemis victoria, sp. nov. (Fig. 1.)

Male. Abdomen, 15 mm. Hind-wing, 11 mm.

Head: labium whitish-yellow; labrum glossy black, non-metallic; rest of head, including back of eyes, matt-black, except for a small round postocular azure blue spot on each side of occiput; bases of mandibles and cheeks pale yellow.

Prothorax matt-black, the hinder part of sides, including extremities of posterior lobe, azure-blue.

Thorax black on dorsum, greenish-yellow to citron-yellow on sides; a narrow azure blue humeral stripe on both sides of dorsum broadening gradually below, and a broad black stripe on the hinder lateral suture.

Legs black, tibiae yellow on extensor surface, femora pruinosed white on flexor surface.

Wings hyaline; pterostigma greenish-grey or dirty yellow framed in black; 7 to 8 postnodals to fore-wings, 5 to 6, usually 5 in the hind; arc widely distad of the distal antenodal.

Abdomen bluish-green to yellowish laterally and beneath, broadly marked with black on dorsum; segments 9 and 10, and segment 8 in tenerals, rust-red; segment 1 broadly black on dorsum; segment 2 with a black dorsal marking similar to that found in *A. splendidissima*, but without the two eye-spots; 3 to 6 with narrow dorsal black stripe, which broadens at apical ends of segments; 7 with a much broader dorsal marking, whilst 8 to 10 unmarked.

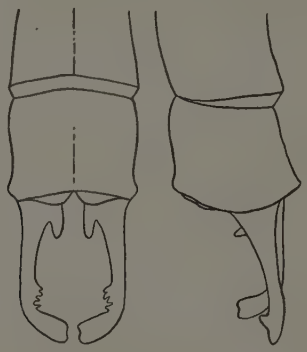


Fig. 1.—*a*. Dorsal view of anal appendages of *Agriocnemis victoria*, sp. nov. ♂. *b*. Profile view of same seen from the left side.

Anal appendages. Superiors one and a half times as long as segment 10, ferruginous changing to black at apices. Broad at base, where they are furnished with a very obtuse short pale yellow spine directed inwards and downwards, tapering thence to apex, which is slightly spatulate and turned inwards and downwards. On the inner side of appendage, quite near the apex, a small boss furnished with 4 or 5 small black teeth. Inferior appendages not visible in profile, small yellow inconspicuous tubercles curled on themselves and hidden beneath the ventral margins of segment 10.

Female. Abdomen, 16 mm. Hind-wing, 12 mm. (Heteromorphic.)

Andromorph. Head and prothorax coloured as for male, but labrum bordered with creamy yellow and postocular spots absent. Thorax with the humeral stripes and sides yellow, the former almost obsolete in full adults.

Legs with flexor surfaces and proximal ends of femora yellow.

Abdomen bluish-green at the sides, broadly black on dorsum, including the terminal segments. Segment 1 with a broad quadrate dorsal black spot; 2 with the dorsum broadly black, the margins of this marking sinuous, and an additional oval narrow diffuse black spot on sides of segment; other segments as for male, but the basal expansion of black

sending off a lateral prolongation basad exactly as in *A. splendidissima*. Segments 8 to 10 blackish brown, paler laterally.

Anal appendages short, conical, dark reddish brown.

Wings as for male, 7 to 8 postnodal nervures to fore-wings, 6 in the hind.

Heteromorph. Head similar to andromorph, but with a bright orange occipital marking shaped as an irregular pyriform lobe on each side, connected across occiput by a narrow stripe.

Prothorax as for last; thorax also similar, but markings and sides bright blood-red, paling to rose-pink low down on sides. Legs with black markings more restricted.

Abdomen blood-red, the intersegmental nodes finely ringed with black, otherwise unmarked. Anal appendages red with black tips.

Distribution.—Two males and two females, collected by Dr. G. Hale Carpenter on the north-west shores of Lake Victoria, Uganda, July—September, 1927.

The species belongs to the *splendidissima* group, a group mainly confined to S. Asia.

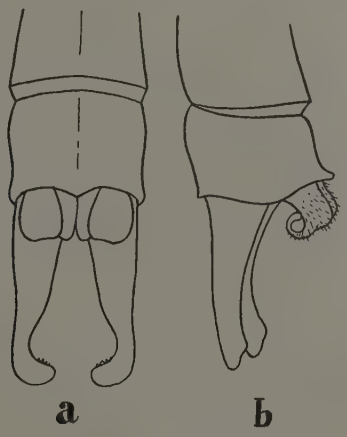


Fig. 2.—*a*. Dorsal view of anal appendages of *Agriocnemis maclachlani*, Selys, ♂. *b*. Profile view of same seen from the left side.

Agriocnemis maclachlani, Selys. (Fig. 2.)

Dr. Hale Carpenter has taken several specimens of this very rare insect, which, so far as I am aware, has not been met with since it was first described by its author in the year 1877. The type is a male in the Selysian collection, and there are paratypes in the MacLachlan collection. All the present examples are heavily pruinosed, the thorax being quite white in some. It is remarkable, in the genus, for its large size.

Distribution.—Type from Senegal. Present specimens from the west shore of Lake Victoria, Uganda, July—September, 1927.

As the anal appendages show a wide departure from any others of the genus I have given a figure of them.

Libyagrion, gen. nov.

Small Zygopterons of dull colouring and slender long abdomen. Venation: quadrilateral in fore-wing with costal side less than half the length of hinder, that of hind-wing with the costal side half the length of hinder, outer angle very acute; arc at the 2nd antenodal or very slightly distad; *ac* situated nearly midway between the two antenodals, the end of *ab* lying a little proximad to it—that is, petiolation begins slightly proximad of *ac*; 3 cells between the quadrilateral and the subnode; pterostigma unicolorous in all wings, that of fore-wing nearly twice the size of that of hind; areolets mainly four-sided; reticulation very simple and open.

No postocular spots; posterior lobe of prothorax rounded, simple; dorsum of 10th segment simple, without tubercles on carina; 8th segment of female with a ventral spine. Abdomen very long and attenuated. Anal appendages simple. Legs very short, with few spines.

Libyagrion is evidently closely allied to *Enallagma*, but the extremely long abdomen is quite foreign to the latter and seems of sufficient importance to throw it out of that top-heavy genus.

Libyagrion decoloratum, sp. nov.

Male. Abdomen, 25·5 mm. Hind-wing, 16 mm.

Head: labium palest fawn; labrum and epistome pale reddish-brown; rest of head darker reddish-brown with a black marking anterior to occiput shaped like a maltese cross with the hinder limb missing; eyes pale fawn beneath, warm brown above.

Prothorax pale fawn at the sides, reddish-brown on dorsum, including posterior lobe.

Thorax bluish-grey, the dorsum ochreous with a fine blackish-brown line on each side of, and parallel with dorsal carina; a diffuse pale reddish clouding bordering the humeral suture, which has a small black spot at its upper limit. Legs carneous, with short black spines.

Wings hyaline; 9 postnodals in fore-wings, 8 in the hind; pterostigma pale reddish-brown.

Abdomen bluish-grey with a narrow blackish-brown stripe extending from the dorsum of segment 1 to segment 7, expanding on each segment subapicad and confluent with a very narrow ring at the intersegmental nodes; segments 8 to 10 azure-blue, unmarked.

Anal appendages carneous, the superiors as long as segment 10, small conical organs, flattened from above down, broad at base, bluntly rounded at apex; inferior appendages half the length of superiors, short pencil-like organs directed obliquely up towards the superiors and ending in a subacute point.

Female. Abdomen, 23·5. Hind-wing, 16 mm.

Exactly similar to the male, but the dorsal markings on abdomen extending as far as the middle and proximal thirds of segment 8, and somewhat broader in extent. The black on head forms an unbroken band across the ocellar space; pterostigma palest pink, of the same size in all wings; 10 postnodal nervures in fore-wings, 9 in the hind.

Distribution.—Zomba, Nyasaland Protectorate. A single pair apparently taken *in cop.*, by Mr. Colin Smee.

Aciagrion attenuatum, sp. nov.

Male. Abdomen, 35 mm. Hind-wing, 24 mm. (Female unknown.)

Head: labium white; labrum dark brown, the anterior border paler; rest of head dark purplish-brown; occiput and behind eyes pale olivaceous-brown; eyes dark brown.

Prothorax warm brown on dorsum, bluish laterally, the posterior lobe rounded, simple.

Thorax pale blue on sides, dark reddish-brown on dorsum, with a small black spot at the upper limit of each lateral suture.

Legs pale yellow with a few very short black spines.

Wings hyaline, reticulation brown, areolets mostly four-sided; pterostigma brown in a darker brown frame, inside which is a second paler frame; the pterostigma of fore-wing rather larger than that of hind. *Ac* meets the extreme end of *ab* on wing margin; 3 cells between the quadrilateral and subnode; 12 postnodal nervures in fore-wing, 11 in the hind.

Abdomen markedly long and attenuated, expanding somewhat towards the end, pale yellow laterally, marked with dark reddish-brown on the dorsum, this colour expanding at the apex of each segment into a very broad black ring; segments 8 to 10 entirely azure blue.

Anal appendages warm dark reddish-brown. Superiors shorter than the 10th segment, small conical organs. Inferiors much more robust, equal in length to segment 10, conical and very bluntly pointed as seen in profile, laterally compressed as seen from above, convex externally, concave internally, the apex curling slightly in, so that the appendage is shaped like a boxing-glove without the thumb portion.

Segment 10 on dorsum very narrowly and very shallowly emarginate.

Distribution.—A single male from Zomba, Nyasaland Protectorate, collected by Mr. Colin Smee.

I have hesitated before placing this species in *Aciagrion*, as no other species have so far been reported from the continent of Africa. This argument, however, loses force when we consider how many others of the smaller Asiatic Odonate genera are represented in Africa. The species is not unlike *olympicum* from the Himalayas belonging to the same genus. For lack of material, and in order not to spoil the only known specimen, I have forborne to dissect out the penis, which might tell us much.

Copera subaequistyla, sp. nov.

Male. Abdomen, 29 mm. Hind-wing, 16 mm.

Head: labium pale yellow; labrum dull olivaceous; anteclypeus pale greenish; postclypeus, frons and vertex black crossed by a narrow pale olivaceous stripe running from eye to eye; behind eyes and occiput a similar narrower stripe, whilst a narrow reddish-brown border intervenes between the black and the eyes on dorsum of head; eyes dark brown, paler below.

Prothorax dark ochreous enfumed with black.

Thorax blackish-brown on dorsum, bright yellow on the sides. The humeral suture marked rather broadly with bright yellow; the sides with the central portions of mesepimeron and metepimeron irregularly black. Legs reddish-orange, tibiae not dilated.

Wings hyaline; pterostigma dark reddish-brown framed first in pale ochreous and then in black; postnodals 11 in fore-wings, 9 in the hind.

Abdomen: segments 1 and 2 dark ochreous, the latter with a subapical obscure blackish annule narrowly interrupted on the dorsal carina; segments 3 to 7 with a narrow basal white annule, which is nearly interrupted on the dorsal carina, and laterally is continued apicad to near apical end of segments; the dorsal carina very finely yellow from segment 3 to middle of segment 6; segment 8 and 9 black, unmarked, segment 10 yellow on dorsum with a fine black line at base and apical border.

Anal appendages: superiors yellow, half as long again as segment 10, conical, broad at base, tapering to a subacute point at apex; inferiors more robust, one-fourth longer than superiors, black, conical, tapering to a sharp point, very broad at base as seen from below,

presenting a rounded projection on the inner side at a little more than half-way from base to apex. (Both pairs of appendages are narrowly separated, parallel, and project straight back as in *C. marginipes*, which insect this species greatly resembles.)

Female. Abdomen, 26 mm. Hind-wing, 18 mm.

Head: lips, anteclypeus and front of head similar to the male, the black of vertex arrested before the level of the anterior ocellus, the surface posterior to it, including occiput, ochreous, as also the basal segments of antennae. The occiput with a diffuse obscure clouding of black; the cheeks greenish-yellow, this colour continued as an equatorial band round the eyes.

Prothorax and thorax very similar to the male, but the black on sides forming a very broken fascia and the whole surface splashed with small yellow spots.

Legs yellow, hinder surfaces of femora black.

Wings with 11 postnodals in fore-wings, 10 in the hind, pterostigma as in male.

Abdomen less broadly marked with black on dorsum, this forming broad apical rings, the surface basad to which is dark reddish-brown, except at extreme base, where are narrow white annules. The dorsal carina finely yellow as far as end of segment 7; segment 10 and apical half of 9 paler, probably yellow during life.

Anal appendages dark, short, conical.

Distribution.—Shores of Lake Victoria, Entebbe, Uganda. Two pairs, *in cop.*, collected by Dr. Hale Carpenter, July—August 1927.

The resemblance to the two Asiatic species, *C. marginipes* and *vittata*, is surprising when one considers the vast barrier of sea which intervenes between the two faunal areas. No connecting links are known, nor is it at all likely that any species will be found in the area connecting up the two continents. With so little variation and mutation, it is impossible to believe that the species can have been for long separated. These small Zygopterons when emerging, rise straight into the air. I have watched them ascend to vast heights, until finally lost to sight. No doubt, in spite of the enormous distance to be covered, these insects rely on air currents for distribution, their very weakness, their gossamer-like lightness, being their strength. The minute species of *Agriocnemis*, *Disparoneura* and *Pseudagrion*, etc., are parallel examples of wind-borne distribution, so far as Africa is concerned.

Chlorocnemis marshalli, Ris.

The female of this species has not been described, the type, a male in the British Museum, and one other in Mr. E. B. Williamson's collection, being the only specimens known. Mr. Colin Smee has rediscovered this beautiful insect at Zomba, Nyasaland, and has kindly sent me several males and two females, from which the following descriptions have been made.

Female. Abdomen, 38 mm. Hind-wing, 24 mm.

Closely similar to the male; differs as follows: antehumeral lines much narrower; wings coloured greenish-yellow in the middle three-fifths only, the apices and bases being quite uncoloured; 18 to 20 postnodal nervures in fore-wings, 15 in the hind; segment 1 with a black quadrate dorsal spot, segment 2 with a narrow middorsal longitudinal carinal stripe of blue limited to the basal half of segment, the rest of segment unmarked, segments 3 to 7 with small paired blue basal spots, segment 8 azure-blue with a longitudinal lateral thick black stripe, the blue beneath which very pale, almost white, segment 9 with a dorsal bell-shaped blue spot, the broad end of the spot not extending quite to apical border of segment; segment 10 unmarked.

Anal appendages black, short, conical.

The males agree entirely with the description by Dr. Ris, but one example, fully adult, has the colouring of the wings very poorly marked, and limited to a space lying between the node and half-way from that structure to the pterostigma.

Fore-wings with 17 postnodal nervures, hind with 14; length of abdomen varying from 37 to 40 mm. Legs of both sexes bluish-white, the tibiae and tarsi black, as also the extensor surfaces of the middle and hinder pair of femora and the whole of anterior pair except the proximal end. Claw-hooks situated at extreme end of claws, so that the latter appear to be bifid.

Metacnemis pruinosa, sp. nov. (Fig. 3.)

Male. Abdomen, 33 mm. Hind-wing, 25 mm.

Head: labium carneous, pruinosed at centre of middle lobe; labrum and cheeks olivaceous; rest of head matt-black, the vertex and occiput heavily pruinosed white; eyes blackish-brown.

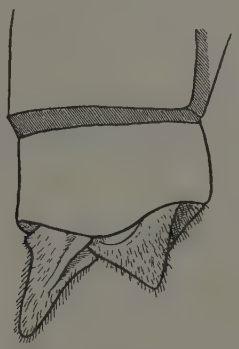


FIG. 3.—Lateral view of anal appendages of *Metacnemis pruinosa*, sp. nov. ♂ seen from the left side.

Prothorax black heavily pruinosed white.

Thorax black on dorsum, pale yellow on sides posterior to first lateral suture, the black parts heavily pruinosed, including a narrow black stripe on the second lateral suture.

Legs black, flexor surface of hind femora and the proximal portions of the middle and anterior pairs yellow, all thinly pruinosed.

Wings hyaline; pterostigma palest brown framed in black; 18 postnodal nervures to fore-wings, 15 to 16 to the hind; venation similar to but rather closer than in *M. valida* or *robusta*; 5 cells between quadrilateral and subnode in fore-wings, 4 in the hind, as for *valida*.

Abdomen black, unmarked, dorsum of segments 1 and 2 and an apical spot on dorsum of segments 3 to 5 thinly pruinosed, segments 8 and 9 pruinosed white.

Anal appendages black. Superiors as long as segment 10, broad at base, where they show an angulated broadening above and, on the inner and underside, each a spatulate-like process prolonged inward to overlap one another; tapering to an acute point, and directed straight back parallel to one another. Inferior appendages much smaller, about half the length of superiors, tapering to an acute point as seen in profile, excavate within and curled on themselves as seen from behind, very broad at base, directed straight back parallel to one another and to superiors.

Female. Abdomen, 29 mm. Hind-wing, 25 mm.

Head: labium as in male; labrum olivaceous-yellow; rest of head plumbeous or violaceous-brown without markings.

Prothorax pale brown, the middle lobe raised into two rounded bosses, the posterior lobe reduced to two small lateral lobes, between which projects a rounded lappet on anterior surface of thorax.

Thorax olivaceous-brown, the middorsal carina and the postero-lateral suture finely black.

Legs black, the flexor surfaces of femora olivaceous, the extensor surfaces of tibiae yellowish.

Wings uncoloured; pterostigma very pale brown, finely framed in black nervures; 17 or 18 postnodal nervures in fore-wings, 15 in the hind; other details of venation as in male.

Abdomen dark reddish-brown with the joints ringed with black, and segments 2 to 6 with subapical black dorsal spots, between which and the black joints are obscure yellow rings. In tenerals the ground-colour ochreous, the black rings and spots very conspicuous; segment 8 has a medial subdorsal black spot on either side the dorsal carina, 9 has a subdorsal stripe running from the base nearly to apical border of segment, whilst 10 is unmarked. In adults, these three last segments entirely blackish-brown. Anal appendages very short, conical, brown.

Distribution. Eastern Province, Budama, and Bunyuli Districts, Uganda. Three males and two females collected by Dr. Hale Carpenter, October, 1927.

Closely allied to *M. valida*, Selys, differing by the colour of wings and pterostigma, etc.

Sub-order *ANISOPTERA.*

Echinopterogomphus africanus, Fras. (Fig. 4.)

I described this species in the *Trans. Ent. Soc. Lond.*, Dec. 21, 1926, from an imperfect male, teneral in condition and lacking the last seven segments of the abdomen. This specimen, the type, now in the B.M. collection, was taken at Port Lokko, and formed, as I have since discovered, part of the collection made by Dr. James Simpson.

By a happy coincidence, its author has now come into the temporary possession of three adult males and a single adult female, all in excellent condition, collected by Dr. G. Hale Carpenter in the Gulu District, Uganda, June—July, 1927, and is thus in a position to give not only the full colouring and markings, but also to complete the description of the missing abdomen and genitalia of both sexes of this remarkable species.

Male. Abdomen, 28 mm. Hind-wing, 19–20 mm.

Head: Labium pale yellow, bases of all lobes brownish; labrum creamy-yellow, the anterior border finely, the base very broadly black, a median point of black projecting from the base, but arrested well short of the anterior border of lip; bases of mandibles and anteclypeus creamy-yellow; postclypeus similarly coloured, but its base broadly black save for a small median point of yellow; frons pale greenish-white, its base and the lower margin of anterior surface narrowly black; vesicle black; occiput pale greenish-white in a narrow frame of black, its hinder border notched and showing two convexities.

Prothorax black, the whole of the posterior lobe, a large spot on each side of the median lobe, a broad anterior collar and a tiny germinate spot on middorsum of median lobe citron-yellow.

Thorax black, marked with citron-yellow as follows: a median spot on antealar sinus confluent with the middorsal carina, which is finely yellow above and then broadens into an even median carinal stripe confluent with a short complete mesothoracic collar below; an antehumeral short fusiform oblique spot on either side of middorsum; a narrow complete humeral stripe with sinuous, bayonet-like bend above; laterally and beneath entirely yellow save for a fine black line on the first lateral suture interrupted at its middle, and a second similar line on the second suture interrupted below.

Legs bright yellow; tibiae, tarsi and a stripe on the outer side of femora black, broadest on the anterior pair, nearly obsolete on the hinder.

Wings hyaline, very palely suffused with greenish, reticulation yellow including costa; pterostigma yellow between thick black nervures; details of venation as for genus; base of hind-wing and tornus (in all males examined) with the characteristic spines, the tornal one

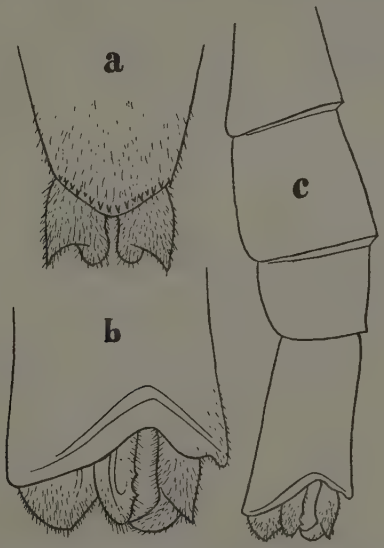


Fig. 4.—*a*. Dorsal view of anal appendages of *Echinopterogomphus africanus*, Fras. ♂ *b*. Profile view of same seen from the right side. *c*. Terminal segments of abdomen of same to show the curious relative lengths.

yellow with a black tip; 12 to 14 antenodal nervures and 10 to 12 postnodals to fore-wing; 10 to 12 antenodal nervures and 9 to 11 postnodals to hind.

Abdomen ochreous marked with black on segments 2 to 7, reddish ochreous on segments 8 to 10. Segment 1 greenish-yellow with a subdorsal basal black spot on either side; segment 2 with a subdorsal clouding of blackish-brown on each side; 3 to 7 with apical black rings with which is confluent a broad black lateral stripe not quite extending to base of segments. Segments 1 and 2 tumid, 3 to 6 narrow and cylindrical, 7 to 9 dilated somewhat, 10 cylindrical. Segment 9 about two-thirds the length of segment 8, segment 10 nearly as long as these two last segments taken together, its dorsum prolonged into a blunt point and with a very deep incision on each side.

Anal appendages reddish-brown, only about one-fourth the length of segment 10; superiors subcylindrical, seen from above very broad and cleft into an outer short robust spine and an inner rounded tubercle, seen from the side the outer part showing the

same robust spine, whilst the inner is seen to be strongly curved down and shaped like a parrot's beak. Inferior appendage slightly shorter than superiors, with blunt rounded apex, deeply cleft and presenting two small points above, one median, the second midway between it and apex. Dorsum of segment 10 with many robust apical spines.

Genitalia. Lamina depressed; anterior namules robust spines, broad at base, tapering gradually to apex; posterior hamules very broad, foliate and somewhat quadrate, bearing two or three small black spines on anterior corner; lobe spout-shaped, projecting markedly, emarginate.

Female. Abdomen, 31 mm. Hind-wing, 23 mm.

Similar to male, except for a few minor and sexual details. The hind femora with spines more robust, less numerous, black; the anterior pair of femora alone marked outwardly with blackish-brown, the other pairs with an almost imperceptible clouding. Abdominal segment 2 unmarked save for an obscure basal clouding of dark brown on each side.

Wings more deeply suffused with greenish-yellow; pterostigma golden-yellow between thick black nervures, surmounting 5 to 6 cells, strongly braced; base of hind-wings 1 to 2 cells deep, without marginal spines, very oblique, almost as in *Pseudophaea*; nodal index: 12 to 13 antenodals to fore-wings, 9 to 11 postnodals; 10 to 11 antenodals in hind-wings, 9 to 11 postnodals.

Relative lengths of abdominal segments as in male; anal appendages very short, conical; vulvar scale triangular, deeply bifid so as to form two minute triangular scales, about half the length of segment 9.

Distribution.—Type from Sierra Leone, the present specimens from Uganda

It is quite impossible to determine the relationships of this remarkable *Gomphus*; its anal appendages are unique; the contracted, oblique base of hind-wing suggests an archaic species lying somewhere near the base of the family Gomphidae, but this is not borne out by other features in the venation. I am inclined to think that undue importance has been placed on the basal reduction of the hind-wing in the Anisoptera, and that we should in many cases rather regard it as a modern reduction in the surface of the wing to satisfy the modest requirements of small insects—thus we find a similar, although not quite so marked, reduction in most of the smaller Gomphines, such as *Progomphus*, *Microgomphus*, etc.

The relative lengths of the terminal abdominal segments are not unlike those of *Macrogomphus* of S. Asia, but there the resemblance begins and ends.

Nilogomphus, gen. nov.

Medium-sized Gomphines coloured black with yellow markings; head moderately large; frons pronounced, slightly rounded; occiput in the male straight, flat, a little tumid at its centre behind; in the female with a prominent transverse ridge at its middle, the hinder border raised and markedly convex.

Thorax comparatively small. Legs long, the hind femora extending as far as the hinder border of segment 2, armed with 2 rows of short, evenly-sized, closely-set spines on rather more than the proximal half of limb, and with four pairs of long, robust, widely-spaced, evenly-sized spines on the distal end; mid-femora with rows of closely-set minute spines; claw-hooks robust, situated at centres of claws.

Abdomen tumid at base, slim and cylindrical from segment 3 to 7, dilated at 8 and 9, almost winged; segments 7 to 10 decreasing gradually in length. Anal appendages closely similar to those of *Anisogomphus*, the superiors parallel and armed with a robust ventral spine, the inferior with widely divaricate branches projecting widely laterally beyond superiors.

Wings comparatively long and broad for size of insect; reticulation moderately open; pterostigma very short and broad, strongly braced; membrane absent; sectors of arc parallel for a short distance, especially in the hind-wings; triangles entire, that of hind-wing subequilateral, but distal side slightly longer than the others, that of hind-wing elongate, distal side twice as long as basal and slightly longer than costal; *IA* in fore-wing short, markedly pectinate; Cu_2 and *IA* parallel nearly as far as wing-margin in the hind-wing; 2 transverse nervures between *Rs* and *MA* in fore-wing, only 1 in the hind; 4 rows of postanal cells in hind-wing, only 1 or occasional double cells in fore-wing; 1st postanal cell of hind-wing divided, extending proximad to a point on the base of subtriangle slightly proximad of its middle; anal triangle 3-celled; an incomplete basal antenodal nervure in all wings.

Genitalia. (See under species.)

Female with similar armature to femora, but the robust spines more numerous and extending to middle or proximad of middle of femora; abdomen cylindrical throughout, dilation of end segments less marked than in male; vulvar scale short, triangular, projecting slightly as seen in profile, notched at its apex; pterostigma more broadened and more heavily bordered than in the male.

Genotype: Nilogomphus carpenteri, sp. nov.

Distribution.—Central Africa.

Its apparent relation to *Anisogomphus* is probably due to convergence, the highly characteristic shape of pterostigma serving to separate the two genera.

Nilogomphus carpenteri, sp. nov. (Fig. 5.)

Male. Abdomen, 27 mm. Hind-wing, 25 mm.

Head: labium with midlobe black, lateral lobes citron-yellow; labrum glossy black with a large oval citron-yellow spot at each outer end; ante- and post-clypeus black, the latter with a small outer spot of yellow; frons pale greenish-yellow, its base above and its anterior surface below margined with black; vertex black with a transverse stripe of greenish-yellow just posterior to the ocelli; occiput greenish-yellow, fringed with long fine black hairs and finely bordered with black.

Prothorax black with a broad oval spot on dorsum of posterior lobe, a small bilobed spot on dorsum of midlobe and a broad anterior collar all citron-yellow.

Thorax black marked with bright citron-yellow as follows: the median suture and upper border of the antealar sinus finely, a very broad middorsal carinal stripe which extends upwards on either side of antealar sinus and is constricted abruptly below just before it becomes confluent with a complete mesothoracic collar; a narrow humeral stripe, sinuous outwardly above, confluent with a large irregular spot below; laterally entirely yellow save for a narrow black stripe on the first lateral suture. Beneath yellow.

Legs black, anterior femora paler on inner sides, trochanters and coxae citron-yellow.

Wings hyaline, palely and diffusely tinted with yellow basad to level of triangles; pterostigma brown, its outer end paler, very heavily bordered with black, especially the costal border, which is remarkably thickened; 2 rows of discoidal cells as far as level of node in fore-wing; nodal index— $\frac{9\text{–}12 \mid 12\text{–}8}{8\text{-}8 \mid 8\text{–}8}$; other details as for genus.

Abdomen black marked with citron-yellow as follows: the sides and dorsum of segment 1 broadly, these areas separated by a subdorsal black stripe which is continued on to segment 2. The latter with a large trilobed middorsal spot and its sides broadly yellow; oreillets yellow at base, bordered heavily with black, very prominent; segment 3 almost entirely yellow, with a subdorsal black stripe partially indenting the dorsal yellow so as to convert it into a dorsal stripe with crenate borders; segments 4 to 6 similar, but the subdorsal black extending over whole of sides, save for a small triangular latero-basal yellow

spot on each side; segment 7 with the middorsum narrowly yellow and the sides broadly so; segments 8 to 10 yellow on sides only.

Anal appendages black tinged with brownish-yellow above. Superiors cylindrical, as long as segment 10; viewed from above, separated by less than their own width, with concave inner border, parallel, apex tumid and blunt, but furnished with a keel, above which it is prolonged into a long sharp spine; viewed in profile, broad at base, furnished with a very robust spine at about the middle of appendage and ending in an acutely pointed, slightly upwardly inclined apex. Inferior appendage deeply cleft into two widely divaricate branches, which are abruptly curled up at apex and furnished each with a short sharp spine. The combined appendages strikingly similar to those of *Anisogomphus occipitalis* from N. India.

Genitalia. Lamina depressed, cleft to its base; anterior hamules robust stylet-shaped organs directed rather obliquely inward, and with rather blunt apices; posterior

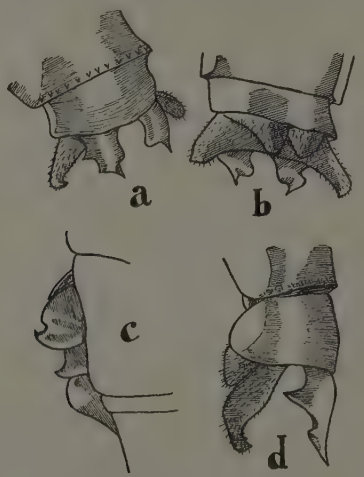


Fig. 5.—*a*. Dorsal view of anal appendages of *Nilogomphus carpenteri*, sp. nov. ♂. *b*. Ventral view of same. *c*. Genitalia of same seen from the left side. *d*. Anal appendages of same seen in profile from the left side.

hamules very broad, longer than the anterior, ending in short, stout, forwardly directed hooks; lobe prominent, corrugated, slightly truncate and markedly emarginate.

Female. Abdomen, 30 to 31 mm. Hind-wing, 28 to 29 mm.

Colouring and markings as in the male, except that the lateral thoracic stripe is broken and the lateral yellow spots on segments 3 to 6 extend as a stripe the whole length of segments; segment 10 has the apical border narrowly yellow, as also the basal halves of anal appendages and the conical protuberance between them. All femora dull yellow on flexor surfaces.

Wings with only the extreme bases tinted yellow; nodal index — $\frac{10\text{–}12}{10\text{–}8} \mid \frac{13\text{–}10}{8\text{–}8}$; discoidal field of fore-wing with 2 rows of cells to a level well proximal of node.

Distribution. A single pair, apparently taken *in cop.*, from Uganda, collected by Dr. G. Hale Carpenter, August—September, 1927. These appear to have been taken on one of the tributaries of the White Nile, Gulu District.

Mesogomphus rusticatus, sp. nov.

Male. Abdomen, 32 mm. Hind-wing, 24 mm.

Head: labium, labrum and anteclypeus pale greeny-grey; postclypeus, frons, vertex and occiput bright grass-green without markings. Occiput with concave hinder border fringed with fine brown hairs and bearing a small tubercle at the centre of its upper surface.

Prothorax pale brownish-yellow; posterior lobe large, grass-green.

Thorax bright grass-green, unmarked save for the postero-lateral suture and sutures forking from it below, which are violaceous brown.

Legs coloured like the thorax, the hind pair of femora and tibiae with obscure brown markings. Spines black.

Wings hyaline, costa pale; pterostigma bright yellow between heavy black nervures, covering 4 cells, strongly braced; 4 cells in anal triangle; nodal index — $\frac{7\text{–}12 \mid 13\text{–}6}{7\text{–}9 \mid 9\text{–}7}$; $\frac{7\text{–}12 \mid 12\text{–}6}{7\text{–}10 \mid 9\text{–}7}$; rest of venation as for genus.

Abdomen grass-green on segments 1 to base of 3, rest of abdomen reddish-brown. Segment 1 with an obscure clouding of warm brown on dorsum, 2 with a diffuse brownish dorsal spot apicad to jugal suture, a similar brown clouding at the base on each side, and a third apicad to oreillets, which are bright green; segment 3 with the jugal suture mapped out in dark brown and its apical half gradually turning dark brown; segments 4 to 7 unmarked; segments 8 to 10 darker, but the expanded sides of 8 and 9 bright ochreous, narrowly bordered with brown.

Anal appendages. Superiors rather longer than the two last abdominal segments taken together, yellow with a greenish tinge, separated in their basal halves by a narrow oval gap, closely apposed in their apical halves, which curve regularly downward to end each in a bifid apex showing two distinct but minute points. The appendages are laterally compressed in the basal half and strongly keeled below. Inferior appendage rather longer than half the superiors, bifid for half its length, its branches parallel and overlapping at apices so as to enclose a small oval space; outer border concave and with a large tubercle at apex. Seen from the side this appendage is strongly curled, at first down, then up, and finally straight back, to end in a blunt apex coated with long coarse white hairs.

Genitalia. Lamina depressed, not visible in profile, broadly and rather deeply concave; anterior hamules broad at base, tapering rapidly, converging and ending each in a minute, outwardly directed spine; posterior hamules much more robust, quadrate plates curling in towards each other and each with a small stout spine at anterior angle; lobe prominent, massive, broad, deeply and broadly concave at tip.

Female. Abdomen, 32 mm. Hind-wing, 27 mm.

Coloured similarly to the male; occiput fringed with brown hairs, furnished with about 12 minute black teeth along the hinder border, which is slightly concave.

Hind femora and tibiae with a well-defined reddish-brown stripe on extensor surfaces.

Wings hyaline; pterostigma similar, but the black borders deeper, so as to reduce the included yellow to a longitudinal narrow stripe, covers 3 to 5 cells; nodal index — $\frac{5\text{–}13 \mid 12\text{–}6}{7\text{–}9 \mid 9\text{–}7}$.

Abdomen marked and coloured as in male; oreillets well defined, green. Anal appendages long, fine, pointed, yellow with black apices. Vulvar scale small but broad, triangular, deeply but narrowly notched.

Distribution.—Two males and one female from the shores of Lake Victoria, Uganda, collected by Dr. G. Hale Carpenter, July—September, 1927.

The bright grass-green immaculate colouring of the head, thorax and base

of abdomen is sufficient to distinguish it from any other species of the genus. It resembles strikingly in colouring and general facies *Onychogomphus walli*, Fras., from Upper Burma, and to a less extent, *Ophiogomphus reductus*, Calv., from Kashmir.

Gynacantha libyana, sp. nov. (Fig. 6.)

Male. Abdomen, including anal appendages, 60 mm. Hind-wing, 52 mm.

Head: labium, labrum and face olivaceous-brown, labrum paler and with a slight yellowish tinge; frons darker brown with two small yellow basal spots above converting the dark brown into a thick capital T; eyes enormous, dark green; occiput very small, black.

Prothorax dark brown.

Thorax olivaceous brown, enfumed with darker brown on dorsum and with a sharply defined black stripe mapping out the 2nd lateral suture. Legs bright reddish brown, knees and tibiae black.

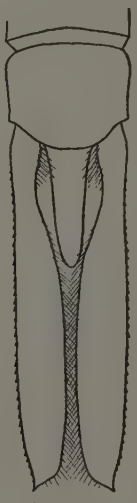


Fig. 6.—Dorsal view of anal appendages of *Gynacantha libyana*, sp. nov. ♂.

Wings very broad, reticulation very close, apices faintly enfumed, bases with a dark brownish ray extending out in subcostal space as far as the 3rd antenodal nervure; membrane black; pterostigma over 6 to 7 cells, yellow between black nervures; 8 to 9 cells in all triangles, the bases of which are reticulate; 11 to 12 hypertrigonals in fore-wings, 8 to 9 in the hind; 11 cubital nervures in fore-wings, 8 to 9 in the hind; 5 to 7 median nervures in all wings; anal loop with 13 to 15 cells; nodal index — $\frac{25\text{–}32}{27\text{–}26} \mid \frac{31\text{–}25}{24\text{–}28}$; only a single row of cells between the origins of Cu_2 and IA; 3 cells in anal triangle.

Abdomen uniform dark reddish-brown, segments 1 and sides of 2 paler olivaceous-brown. Oreillets large, bordered finely with black and with 5 to 7 robust black teeth.

Anal appendages blackish brown, very long, about 7 mm., tumid at base, where are seen some minute spines on the inner surface, then sharply constricted, again dilating, and of about even width as far as apex, where the outer border ends in a small spine, which

is situate at the end of a robust keel running the full length of appendage. Inferior appendage slightly more than one-third the length of superiors, triangular, narrow, curled up at apex, which ends in a short upturned spine.

Distribution.—Shores of Lake Victoria, Entebbe, Uganda. A single male of this fine insect taken by Dr. G. Hale Carpenter.

In size it is comparable to *G. membranalis* from S. America or *G. hyalina* from S. Asia. Its reticulation is closer than in any of the large number of species of the genus I have been able to examine, and even the triangles are reticulated at the base. Its large size and the last mentioned character will suffice to distinguish it from other African species.

Macromia halei, sp. nov.

Female. Abdomen, 50 mm. Hindwing, 48 mm.

Head: labium, labrum and whole of face dark blackish-brown, the frons poorly metallic-green by reflected light; a small yellow spot in each side of the frontal sulcus above, a larger on the sides of frons against the eyes, and a smaller one on the outer side of postclypeus. (In one specimen all these markings very obscure, especially the two small spots on upper surface of frons.) Eyes probably blue or bottle-green during life, as in most of the species. Occiput small, black.

Prothorax blackish-brown.

Thorax very dark uniform reddish-brown, with a bluish metallic reflex, entirely without the usual yellow markings. Legs black.

Wings hyaline, the apices of fore-wings as far proximad as 2 to 3 cells from node a rich golden-yellow, the middles of the areolets being clearer. Bases of all wings with a dark blackish-brown marking lying in a ground-colouring of golden-yellow, as far out as the 2nd antenodal in fore-wings and the 3rd in the hind, the outer border of markings very ragged and serrate, and extending for but a few cells into anal triangle. (In one specimen, the hinder wing irregularly enfumed along the hinder border between M_4 and the triangle.)

Nodal index — $\frac{6\text{–}17}{9\text{–}11}\Big|\frac{16\text{–}7}{12\text{–}11}$; $\frac{7\text{–}15}{10\text{–}11}\Big|\frac{17\text{–}7}{11\text{–}11}$; 4 to 5 hypertrigonals in fore-wings, 2 in the hind; 5 to 6 cubital nervures in fore-wings, 2 to 3 in the hind; anal loop with 11 to 12 cells; 2 to 3 cells between origins of Cu_2 and IA; pterostigma dark brown framed in black, 3 mm. long in fore-wings; membrane very long, black with a white apex; 2 rows of discoidal cells in fore-wings.

Abdomen black marked with citron-yellow, markedly laterally compressed, tumid at base, narrowed from apical end of segment 3 to basal end of 6, segments 7 and 8 not markedly dilated. Segments 1 and 2 unmarked, segment 3 citron-yellow for the whole of its basal three-fourths, the jugal suture outlined in black; segments 4, 5 and 6 with small dorsal triangular yellow spots basad to jugal suture; segment 7 with its dorsum bright citron-yellow for the basal three-fourths, the black of dorsal carina extending into it apicad; remaining segments unmarked. Vulvar scale very short, cleft to its base into two small triangular leaflets. Anal appendages short, conical, black.

Distribution.—Shores of Lake Victoria, Entebbe, Uganda. Two females collected by Dr. G. Hale Carpenter, November, 1927.

This species belongs to the *trifasciata* group. Differs from *M. tropicalis* by its much larger size, by the thorax without markings, etc.; from *M. africana* by its still larger size and by its extreme melanism; and from *M. trifasciata* by the basal black markings of all wings and by the much more restricted abdominal markings. Male unknown.

Phyllomacromia leoni, sp. nov.

Female. Abdomen, 47 mm. Hind-wing, 40 mm. (Male unknown.)

Head: labium, labrum, and anteclypeus reddish-brown, unmarked; frons in front and postclypeus dull coppery-red with coppery reflex; above frons and descending on each side along the front of eyes bright citron-yellow. A small triangle of coppery red at the base of frons above, lying deeply in the sulcus; vesicle metallic-blue, its apex coppery-red; occiput black; eyes probably bluish during life.

Prothorax ferruginous.

Thorax uniform dark reddish-brown with a bluish-green metallic reflex, antealar sinus bright citron-yellow, otherwise no thoracic markings. Legs entirely black.

Wings hyaline, the fore-wings palely saffronated from apex to 2 to 3 cells from node, the base of fore-wing with a mere vestige of dark brown at the root of subcosta, a much larger basal blackish-brown marking in the hind, extending out as far as the 1st antenodal nervure in subcostal space and as far as the first cubital nervure in cubital space. Nodal index— $\frac{7-14}{8-10} \mid \frac{14-6}{10-8}$; 5 to 6 cubital nervures in fore-wings, 3 in the hind; 10 to 13 cells in the anal loop; 3 to 4 hypertrigonals in fore-wings, 2 in the hind; 2 rows, or occasionally a single row of discoidal cells in fore-wing; pterostigma ochreous, bordered posteriorly with black; costa yellow throughout; membrane dark brown with white tip; Cu_2 and IA separated at origin by a single row of two cells, by 1 row thereafter.

Abdomen very dark reddish-brown marked with citron-yellow as follows: segments 1 and 2 unmarked save for a short linear transverse medial lateral stripe on the latter; segment 3 almost entirely yellow, its apex narrowly dark brown; segments 4, 5 and 6 with the basal pupillate pattern of *P. picta*, this pattern formed by two pairs of lunules facing one another, one with its base to base of segment, the other pair with base on jugal suture, thus enclosing a diamond-shaped spot of the ground-colour; segment 7 with practically the whole of dorsum yellow, the ground-colour restricted to the sides and extreme apex of segment; segment 8 with its extreme base yellow, 9 and 10 unmarked.

Anal appendages very small, conical, dark brown. Vulvar scale very small, equal in length to one-third of segment 9, cleft to its base into two small triangular leaflets.

Distribution.—Gold Coast, West Africa, Yegi, Volta river, 13–14.xi.26. A single female collected by Mr. Hargreaves.

This insect, by the characteristic abdominal pattern, is clearly closely related to *P. picta*, but the total absence of thoracic markings will easily suffice to separate it. The occasional single cell in the discoidal space of fore-wings and the obvious dilation of the terminal segments of abdomen serve to place it in *Phyllomacromia* rather than *Macromia*.

THE BRITISH TACHINIDAE (DIPTERA)

By Colbran J. Wainwright.

[Read November 16th, 1927.]

Plates IX–X and Four Text-figures.

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I. Introduction.

The family Tachinidae is an exceedingly difficult one to study, owing primarily to the fact that the greater part consists of species which are very much alike and possess few tangible characters of specific or even of generic value. Unfortunately, moreover, owing doubtless to the fact that the flies are large and conspicuous and everywhere in evidence, they have forced the attention of entomologists, with the result that very many species have been described, and entomological literature is filled with names that one would like to ignore but may not, attached as a rule to wholly inadequate descriptions from which identification is often impossible.

The position is made worse by the fact that the few reliable characters now recognised as of real use were wholly overlooked by the earlier writers, who practically never referred to them at all in their descriptions, so that it is most difficult to make the greater number of the older names fit in with our present knowledge.

Owing largely to the unrecognisability of the species previously described, and the failure to appreciate the value or lack of value of such characters as were observed, the same species was often described again and again, sometimes even by the same industrious author. The *reductio ad absurdum* was reached by Robineau-Desvoidy, who seems to have given a name to every specimen he captured which showed the faintest difference in colour or appearance from its fellows. As an extreme example of the results of his methods may be instanced the case of *Phryxe vulgaris*, Fall, no less than 248 of his names having been sunk as synonyms of this common and widely distributed species by the authors of the "Katalog der Paläarktischen Dipteren" (8), in which work 13 pages have had to be devoted to this one species and its synonymy, surely an example without parallel in the history of Systematic Zoology.

In such circumstances it will readily be seen that whilst it is difficult to describe species so that they can be recognised with certainty, it is infinitely more difficult to decide which name from amongst the many available shall be adopted for a species when it is described; in fact, it would only be possible

to obtain a complete scheme of correct nomenclature by reference to all the original types, and many of them no longer exist.

In this country little has been published about these insects since the appearance of Meade's "Annotated List of British Tachiniidae" in 1891–1892 (6) and its Supplement in 1894 (7); and as he wrote at a time when serious study of the group had progressed but little it is scarcely a matter for wonder that his papers possess small practical value to-day. His identifications and classifications were based chiefly upon the writings of Schiner (1) and Rondani (2), two excellent naturalists who undoubtedly advanced the study of these interesting insects, but whose classical works were written at a time when too much reliance was placed upon colour and other characters now seen to be of little value.

Since Meade's time much important work has been done abroad. Without doubt the most noteworthy and valuable publications have been those of Brauer and von Bergenstamm, and in particular their classical "Vorarbeiten zu einer Monographie der Muscaria Schizometopa (exclusive ANTHOMYIDAE)," 1889–1894 (3), which is a mine of valuable information. Unfortunately it has proved extremely difficult to utilise much of the information contained in this important work, owing to the complicated and confused manner in which it has been presented. It has, however, revolutionised the study of the group, owing to the attention called to many characters previously overlooked, and in particular those afforded by the head, its shape, and the relationship of the different parts, and its chaetotaxy. A most valuable series of drawings in illustration of the structures to which attention is directed form perhaps the most useful part of the publication. Brauer and von Bergenstamm were fairly successful in their differentiation and limitation of genera, their chief fault in this connection being a tendency to create too many genera and to separate them upon trivial characters of no more than specific importance. They, however, failed lamentably in their attempts to arrange the genera into larger groups, and never seem to have had any real grasp of the main lines upon which the classification of the family should proceed. In fact, although they added greatly to our knowledge, they failed to reduce that knowledge to order.

Girschner, in certain modest little papers (4, 5, etc.), finally provided us with the basis of a promising classification of these insects, and although some of the characters to which he attached importance are of doubtful value and some of his conclusions probably will not be finally accepted, yet he has doubtless brought us within measurable distance of an understanding of the correct grouping of the MUSCIDAE as a whole. He called attention to some most valuable characters, notably in connection with the chaetotaxy of the thorax, and the structure of the abdominal segments, especially with regard to the relations of the sternites and tergites.

The appearance in 1907 of the third volume of the "Katalog der Paläarktischen Dipteren" (8), which dealt with this family amongst others, marked a very important stage in the progress of the study of the group. It is largely to the labours of Prof. Mario Bezzi, who was, we believe, responsible for this portion of the "Katalog," that we owe this epoch-making work, and its value to students can scarcely be over-estimated. It crystallised a great mass of amorphous matter, and it is understood that the arrangement followed is largely based upon the above-mentioned views of Girschner's, worked out in detail with convincing results, so that something approaching a satisfying classification has been reached.

It is much to be desired that someone would do the corresponding portion of the larger "Catalogus Dipterorum," which remains in the incomplete condition in which it existed at the outbreak of the War.

Entomology owes much to my friend Dr. Villeneuve of Rambouillet who, by his invaluable investigations of types and careful identification of species and in many other ways, has contributed largely towards the reduction to something like order of our knowledge of these insects. Possibly the full value of his services to science may never be appreciated, because so many of the fruits of his labours have been given to the world by other workers, whom he has unselfishly and ungrudgingly assisted; and I am glad to be able to acknowledge my own indebtedness to him in this respect, for most of such merit as my own work may possess is due to him.

He has recently (1924) published a very important paper entitled "Contribution à la Classification des Tachinidae Paléarctiques" (18), in which the Girschner system and methods are carried a long way further towards the ultimate ideal, but unfortunately the foundations of the present work were already laid before this important publication appeared, so that it was impossible to base it upon the system therein developed by Dr. Villeneuve.

Again unfortunately, most of this paper had been completed before several valuable recently published works came to hand, so that full advantage of their use could not be taken. Stein's (24) posthumously published "Die verbreitetsten Tachiniden Mitteleuropas" appeared in 1924. This distinguished entomologist, formerly chiefly known as the authority on the Anthomyidae, had been occupied upon this handbook to the mid-European Tachinidae at the time of his death, and it was sufficiently advanced for Kramer to be able to edit it and see it through the press. As a help towards the identification of about 700 species it is very valuable and indispensable to every student of the group.

Lundbeck's (28) outstanding volume on the Tachinidae of Denmark appeared only last year, 1927. This excellent work is in so many respects a model of what such productions should be, that it has left me regretting that I cannot find the time to scrap all I have done and start again to his pattern. The classification and arrangement throughout are based upon Dr. Villeneuve's views referred to above, and mark a definite advance in method and treatment, and there is included much important detail regarding synonymy, biology, etc. Being written in English it will undoubtedly prove a popular and valuable aid to British students of the family, especially as about 200 of the species are common to both countries. As Dr. Villeneuve says in writing to me: "what a pity that he had such a comparatively small fauna with which to deal." So far as possible, advantage has been taken of the appearance of the last two works to correct and bring up to date much synonymy, etc. Two other recent works should be mentioned: Baer's (30) "Die Tachinen als Schmarotzer der schädlichen Insekten," which appeared in 1921, in which is collected together a mass of information regarding the hosts and life-histories of these insects, and Müller's (31) "Über den Bau des Penis der Tachinarier," with drawings, etc., of the genitalia of many of the species.

This present work is offered merely as a tentative list of the British species of the family so arranged that it is hoped that it will prove of service to the increasing numbers of British students whose work, economic and otherwise, brings them into touch with some of these insects, and who desire a ready means of identification; and, further, I hope that it may assist the production of a more complete and successful account of the family which I trust will soon take its

place. It is far from exhaustive; scarcely any attempt has been made to connect up with old records, and it is little more than a list of my own captures and collections, so that inevitably there must be many more species to be added yet. The dichotomic tables, which I am hoping may prove to be the most useful part of the whole, are, I fear, of a superficial character, and have been drawn up chiefly with the view of enabling British specimens to be identified readily and not as a considered contribution to scientific classification. There will, of course, be mistakes, I hope not too many.

As a general rule I have followed the nomenclature, arrangement and limitations of the family as given in the "Katalog" (8), excepting that all reference to the Hypoderminae, Oestrinae and Gastrophilinae has been omitted. A few errors have been corrected, but as a rule even where I may disagree with the generic position of a species or some similar conclusion of the authors, I have accepted it for the sake of uniformity.

The "Katalog," following Girschner, divides the great superfamily of the Muscidae or Eumyidae into two main divisions, the Calyptratae or Schizometopa and the Acalyptratae or Holometopa, and then again subdivides the Calyptratae into the two families of the Tachinidae and the Anthomyidae. We are concerned only with the Tachinidae, which can be distinguished from all other Muscidae by the presence on the hypopleura of a short row of small but distinct bristles placed like a screen just in front of each of the metathoracic stigmata or spiracles; also by the disposition of the macrochaetae of the sternopleura, these being usually three in number, two anterior and one posterior.

A useful, but not quite so reliable, secondary character is that afforded by the form of the 4th longitudinal wing-vein. In the great majority of the Acalyptratae and Anthomyidae this vein runs out to the hind margin more or less parallel with the 3rd longitudinal and without noticeably turning up towards that vein; there are exceptions, notably in *Pyrellia*, *Cyrtoneura* and other allied genera of the Anthomyidae, but even in those cases the vein is curved forwards rather than bent, and there is never a sharp angle or any faint suggestion of a cubital appendage. In the Tachinidae on the other hand, excepting in a few rare cases, the 3rd vein is definitely bent forwards towards the 4th, thus forming a hind-marginal cross-vein, and although sometimes the bending is rounded, yet in the greater number of cases it is sharply angulated and there is frequently a cubital appendage. The exceptions to this rule are occasional species like *Cinochira atra*, Zett., and *Morinia nana*, Mg., two small species which it is easy to fail to recognise as Tachinidae on account of the almost straight 4th vein. In all doubtful cases, however, an examination of the hypopleura will remove any uncertainty and settle an insect's position; although Girschner (4) hints at some slight exceptions even to this rule, and Villeneuve (18) quotes some, they are chiefly non-British insects, or if British not at all likely to cause any doubts.

Osten-Sacken in 1881 (16) first called attention to the hypopleural bristles and pointed out that their occurrence was confined to certain Calyptrate Muscidae. Pandellé in 1888 (19, p. 345) not only mentioned them, but pointed out that they were present in certain groups and absent in others, and might prove a useful character for a division of the Muscidae; but it is to Girschner that the credit is due for realising their full taxonomic value, and it was he who adopted it as the critical character upon which he based his division of the Calyptratae. I am myself convinced of the soundness of his views; it is true that classification based upon the arbitrary use of a single character is

apt to be unsatisfactory, and in this case indeed we find the unexpected result that the old subfamily MUSCINAE of Meigen, Schiner and others becomes divided almost equally between the TACHINIDAE and the ANTHOMYIDAE, and that of the two genera of metallic green species sometimes called "greenbottles" one, *Lucilia*, goes into the former family and the other, *Pyrellia*, into the latter one. In such circumstances one might be forgiven for hesitating, but when once the separation has been made one finds confirmation in other characters: in the above-quoted differences between the form of the 4th vein, in the chaetotaxy, in the shape, etc., of the ventral plates or sternites and even in the habits of the flies. Indeed I have been so fully convinced of the reality of the distinctions as to regard *Lucilia* and *Pyrellia* as an interesting case of convergent variation, in species not really closely allied, and perhaps forming a Müllerian group into which would also come *Gymnochaeta viridis*, Fall, and the non-British *Chrysosoma auratum*, Fall.

Two characters which are useful in a rough and ready way for recognition of TACHINIDAE in the field are, first, the position of the wings when at rest. These are usually held in a partially outspread manner, so that the two fore-margins form with one another something approaching a right angle, and the fly as a whole bears a deltoid appearance. A few ANTHOMYIDAE do the same and are easily mistaken at a casual glance for TACHINIDAE, but the attitude is characteristic and is of assistance when one is collecting. Secondly, the general

ADDENDUM.

Page 142, line 33, *for* "the 3rd vein" *read* "the 4th vein."
" " " 34, *for* "the 4th" *read* "the 3rd."

and the latter is not; also the European and American *Parexorista cheloniae*, Rond., differ in the same way, being identical morphologically but differing in their choice of hosts. More recently a paper by De Coursey in *Annals Ent. Soc. Am.* xx, 368, etc., seems to show that in America *Pollenia rudis*, F., has habits quite unlike those observed by Keilin in this country; and it may easily be that this is a phenomenon of more frequent occurrence than we have hitherto suspected.

It may be helpful to refer briefly to those structures and characters which are most largely employed in the following tables, etc.

These are, *first*:—The form and proportions of the head, especially as seen in profile. So seen it will be readily observed that the head presents, as it were, a four-sided figure, and the varying shapes of the figure and the relative proportions of its four sides represent differences of great importance in the general head form. The eye varies greatly in size, sometimes almost filling up the picture, at others being so much smaller as to leave exposed around it a wide margin of the head capsule itself; this margin varies in width in different parts, sometimes being widest in front, sometimes below. The

position of the antennal base varies in relation to the eye and to the general figure; but perhaps the most important and characteristic variations are those of the position of the vibrissaria in relation to the epistoma as seen in profile, and of both to the general head form. Brauer and von Bergenstamm (3) first called special attention to this series of characters, and they published drawings of nearly 300 species, and these are of the utmost value to students of the group. The points require very close observation for their appreciation, and reference to these illustrations is of great assistance.

Secondly. Of similar great importance are the numbers and exact position of those bristle-like hairs or setae called macrochaetae which are so conspicuously developed in this family and indeed constitute one of its chief characteristics. It would seem at first sight unlikely that the exact position and even curve of a bristle could be anything but chance; but so closely do they conform with exact schemes of distribution, etc., that it would seem that there must be physiological and probably phylogenetic reasons for the placing of every one. It was Osten-Sacken (16) who reduced our knowledge of these bristles to something approaching an exact science, and he gave to many of them the names which are now in general use. It is necessary to observe, in particular, the vertical, ocellar, frontal, facial, and genal bristles of the head; all those of the dorsum of the thorax, especially the dorsocentral, acrostichal and praesutural; those of the scutellum, of which the apical pair in particular is often characteristic; those on the pleurae, particularly the sternopleural; those on the dorsum of the abdomen; and finally those of the legs, which have probably not been sufficiently studied hitherto, though there are many useful characters already recognised. A word of caution is, however, necessary regarding these chaetal characters, as they are very liable to variation, and the student must be prepared for this; some individuals have their whole chaetotaxy unusually strongly developed and with others it is the reverse. Bristles normally missing may appear in the robust specimens, probably ill-developed, but sufficiently evident to mislead, and in the weaker specimens bristles which should be strong and evident tend to become thin and hair-like. Sometimes the two sides of an individual will differ, and supernumerary bristles often occur, and yet with all this variation the chaetotaxic characters will probably be found to be the most useful.

Thirdly. There is the wing-venation; of less value in this family than in some others, owing to greater uniformity, there are yet distinctions in the exact shape of the 4th longitudinal vein and especially the upturned apical portion and its relations to the 3rd vein; in the positions of the cross-veins, and in the relative lengths of the several sections into which the costa is divided.

Additional characters are provided by the antennae with the aristae; in the relative lengths of the joints, and the presence or absence of ciliation on the aristae, etc.; by the legs, especially in regard to the greater or less development of the claws and pulvilli; by the ventral plates or sternites, which vary in their relations to the dorsal plates or tergites, and vary also in their development and form, etc., etc.

In order that my references to the head forms may be understood better there is reproduced on Pls. IX and X a series of drawings illustrating diagrammatically a few of the chief types. As already mentioned these characters require very close observation for their proper appreciation, and there are no sharp lines of demarcation between the groups of species conforming to the different types, so that I have indeed found it necessary to place some species

under two headings in the tables; nevertheless I believe that careful study will not only prove their value for identification purposes, but also that these characters are of much true classificatory importance.

Further, I have also found it necessary to prepare diagrammatic drawings of a typical head (see Text-figs. I and II) and to go very fully into the question of the terminology to be employed for this part of the insect, especially as I have ventured to suggest some new terms and modifications or adaptations of old ones. This has been done with much hesitation and diffidence, but I had found that certain parts of the Tachinid head which I desired to indicate exactly had no names which I could trace, and that, in other cases, terms in use had been applied so varyingly or uncertainly that unless I defined my own use of them very exactly there must have remained doubts in the minds of readers. In some cases there is a large number of different terms given by various authors and available for the same structure; and, apart from the obvious fact that I was forced to make a choice from amongst them, it seemed advisable to refer to some of the synonymy involved; in doing this I had the assistance of my friend Mr. J. E. Collin, and I think that I have his approval for every innovation and change proposed. Further, through the kind offices of my friend Prof. Poulton, I also had the assistance of Prof. Gilbert Murray, who was good enough to suggest suitable Greek words or forms for the new terms I desired.

With additional diagrams illustrating the terminology of the chaetotaxy of the thorax (Text-fig. III) according to Osten-Sacken (16), and that of the veins and cells of a typical wing (Text-fig. IV), I hope that an admittedly difficult subject may have been rendered a little easier.

I desire to express my thanks to the numerous kind correspondents who have helped me with material and in other ways, and in particular to my friends Dr. Villeneuve of Rambouillet, of whose invaluable assistance I have already written, and Mr. J. E. Collin, who has constantly encouraged and advised me and helped me through many of my difficulties. Any value this paper may prove to possess will be due largely to these two distinguished Dipterists. I also wish to thank Mr. Terzi for his great help with my drawings.

II. Terminology.

The Head. (Text-figs. I and II.)

In preparing the following list of the terms employed by me for the parts of the Head I should explain that I have followed Osten-Sacken (16) in regarding a conventional system as being of more value for descriptive work than a true anatomical or morphological one, and have therefore made no attempt to settle homologies or ensure morphological exactitude.

Moreover, in dealing with synonymy I make no profession of exhaustiveness, and have merely referred to those words which I have met with myself frequently or in such circumstances as to cause me to regard them as being sufficiently important for mention. Anything approaching a complete synonymy of terms employed by all authors of works on Diptera would be very cumbrous and would prove but a work of supererogation.

Further, there must remain much uncertainty about some of the synonymy, as so many authors have made no attempt to define their use of words, so that one is left with the possibility of misunderstanding and the probability of at least some overlapping.

Robineau-Desvoidy appears to have been the first to attempt in his " Essai

sur les Myodaires," 1830 (10), something like a scheme of terminology for the Muscid head. Many of the names he used were not new, but he proposed a number of fresh ones, some of which have already been generally adopted, and others might well be revived. Though sketchy, his scheme was

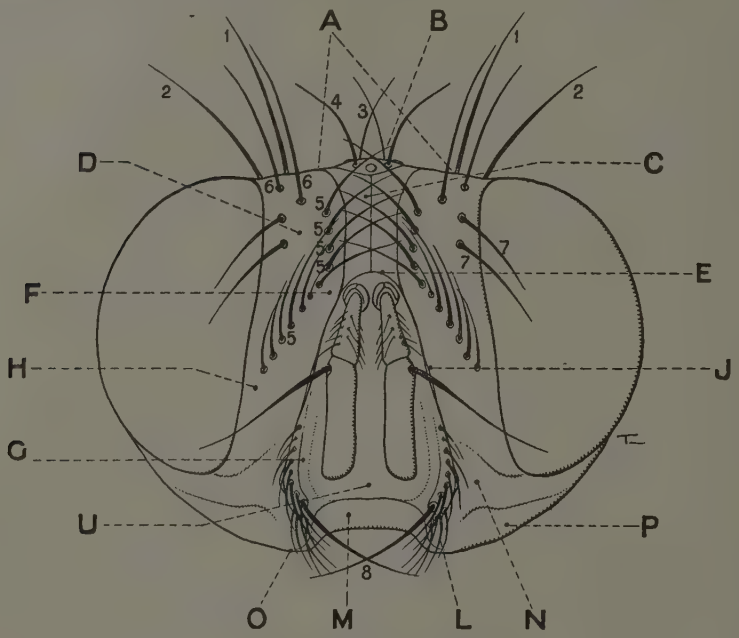

Fig. I.—Head, Front View.

A. Vertex.
B. Ocellarium.
C. Frontalia.
D. Frontorbita.
E. Lunula.
F. Profrons.
G. Facialia.
H. Genae.
J. Ptilinoraph or Frontal Suture.
K. Antennae.
L. Vibrissaria.
M. Epistoma.
N. Medianae.
O. Peristoma.
P. Lateralia and Buccae.
Q. Eyes.
R. Postorbita.
S. Occiput.
T. Postbuccae.
U. Interfacialia.
V. Ptilinope.

Chief Macrochaetae of Head.

1. Inner Vertical.
2. Outer Vertical.
3. Post Vertical.
4. Ocellary.
5. Frontal Series.
6. Praevertical.
7. Fronto-orbital.
8. Vibrissae.

consistent and provided a good basis upon which to erect one more complete, and for the main part I have adopted it and retained his terms.

H. Loew's chapter on Terminology in Vol. I of the "Monographs of North American Diptera," 1862 (17), is another attempt of the same kind, carrying the matter further. He carefully defines his use of the older terms which

he adopts as far as possible, and proposes some new ones; and he has been widely followed. His standing as an entomologist is so high that for that reason alone it is desirable to follow him as closely as possible.

Subsequent writers have supplemented the above and have also employed a variety of alternative terms, but with no definite plan, the chief result being the creation of many synonyms. Many authors, especially German and French ones, have been satisfied to use ordinary colloquialisms; on the other hand, a few, notably some recent American ones, have shown a tendency to ignore the older writers and to create systems for themselves. Most writers, however, have, I think, tended to follow Desvoidy and Loew, though without consistency. I also have followed those authors as closely as I could, and have

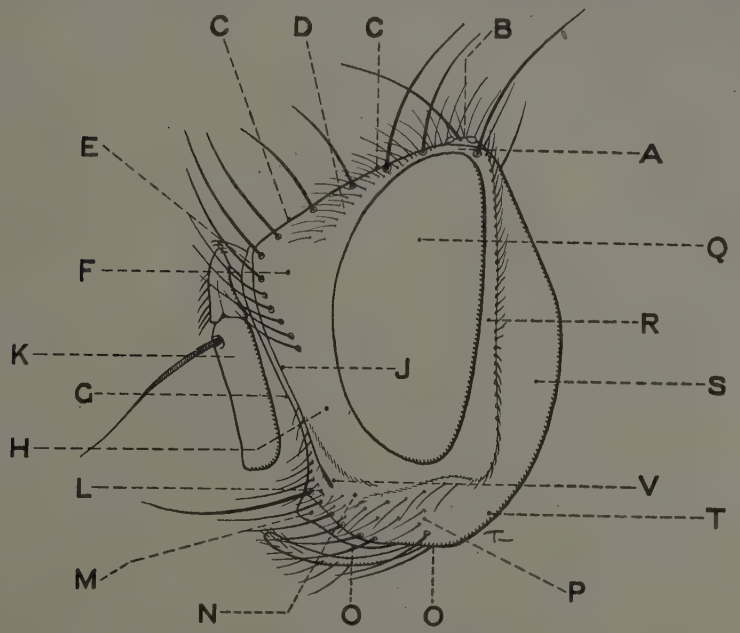

Fig. II.—Head, Side View.
Lettering as in Fig. I.

proposed new terms only when there seemed no old ones available or when for some reason the old ones seemed undesirable, and then I have kept to tradition as nearly as possible. For example, Desvoidy (10) proposed stemmata for the ocellary triangle, but the word was never accepted and most writers have merely used variants of the said term "ocellary triangle"; I therefore have proposed the single word-term ocellarium, which conforms with tradition better than attempting to revive stemmata.

Cranium. The whole exoskeleton of the head minus the eyes and appendages. Actually it is the cranium in its various aspects and parts which alone is dealt with here under the general term Head; the internal anatomy and the details of the mouth-parts, etc., being entirely omitted.

Frons (Figs. I and II, A to E). The whole area situated between the eyes and

extending from the Vertical Margin (A) above to the level of the Frontal Suture at the point where it forks and curves on each side of the Lunula (E) below. Its lower limit has been defined as the base of the antennae (see Séguy (13), p. 5), but the Suture seems to afford a sounder morphological boundary, and the Lunula seems better treated as part of the Facies. It might also be defined as extending from the Vertical Margin to the Profrons. It constitutes part only of the Vertex of Peterson (12); it is the Stirne of German authors; the Bande Interoculaire of Pandellé (19), but the Frons of the great majority of Dipterists.

Vertex (Figs. I and II, A). That part of the Frons at or immediately below the Vertical Margin and extending perhaps as far as the Ocellarium (B), *i.e.* the top of the head. It is the Scheitel of German authors, but the Vertex of nearly all others. Peterson (12), however, uses the term in a different sense altogether.

Vertical Margin (Figs. I and II, A). The actual edge between the Vertex and the Occiput, or between the upper aspect (= the Frons) and the hinder aspect of the Cranium; a term used by Loew (17) (margo verticalis) and Williston (15). Actually the Vertex is not much more extensive than the Vertical Margin, so that separate terms are scarcely required, and they may almost be regarded as synonymous. There are generally two pairs of macrochaetae on or practically on the edge, close to the eyes, and known as the inner (Fig. I, 1) and outer (Fig. I, 2) vertical bristles; and in the centre a trifle behind and below the edge another pair of smaller ones known as the postvertical bristles (Fig. I, 3). Sometimes the former have also been called the temporal bristles. Lundbeck (28) speaks of 2 pairs of postvertical bristles, which he calls the postocellar or inner postvertical and occipital or outer postvertical, but they are not in any case very distinctive. Wingate (27) writes of the Vertical Orbits, which he defines as the sides of the Vertex close to the eyes, but I do not think that such a term is wanted.

Ocellarium (Figs. I and II, B). A slightly raised triangularly shaped area on the Frons just below the centre of the Vertex, upon which are situated the three Ocelli. It also bears a pair of strong bristles known as the Ocellary bristles, usually curved forwards and downwards (Fig. I, 4) and various smaller and less important ones. Desvoidy (11) called it "Stemmata," but the term was never accepted and the majority of authors have referred to it as the Ocellary Triangle or by some similar term such as the German Ocellenplatte, so I have suggested Ocellarium as a single word-term sufficiently in accord with usage and obvious in its application. Williston (15) and Wingate (27) also refer to the Ocellary Triangle as being on and surrounded by the Vertical Triangle, but it seems unnecessary to make a distinction here.

Frontalia (Figs. I and II, C). A band down the centre of the Frons extending from the Ocellarium to the Frontal Suture. Usually very distinct through peculiar coloration and texture. It lies between two rows of bristles, which run practically from the Vertex to a variable point at the level of or below the level of the bases of the Antennae and are known as the Frontal bristles (Fig. I, 5). Most of these curve somewhat forward and inward, but usually one or more of the uppermost ones (Fig. I, 6) curve backwards and are stronger than the others, and these are perhaps closely connected with or even identical with the Praevertical bristles of Villeneuve (18), which see under Frontorbita. This is one of Desvoidy's (11) terms and preferable to any one of the various alternatives which have been employed. Loew (17) called it the Frontal Stripe or Vitta frontalis; Hough (9), Vitta; Séguy (13), Bande mediane frontale; Pandellé (19), the Interorbite, and it is the Stirnstrieme of German authors. It is divided down the middle by the upper portion of the Frontal Suture.

Interfrontalia. A narrow line sometimes in evidence down the centre of the Frontalia, to which this name was given by Desvoidy (11); it indicates the position of the upper portion of the Frontal Suture, the Fissura frontalis of Loew (17); or Epicranial Suture of Peterson (12), and would probably be more satisfactorily referred to as such. It is unimportant and but little noticeable in the TACHINIDAE, but Mr. J. E. Collin informs me that in some other groups of the MUSCIDAE it is

much more than a line and indeed broadens out into a distinct band, and in his opinion could not then be correctly referred to merely as the Epicranial Suture, so that Desvoidy's term may be useful in such cases. It seems probable, however, that even in those cases it is merely a manifestation of the Suture and represents nothing different; though Desvoidy seems to have thought otherwise, and writes as if he had observed two distinct and separate sclerites in between the two portions of the Frontalia.

Frontorbita (Figs. I and II, D). Those portions of the Frons lying between the Frontalia and the Eye-margins. These, the Genae, and the Lateralia, together with the Postorbita constitute the Orbits, references to which are most uncertain and confused. Many terms have been employed with varied application, and there has been not only overlapping, but the same name has been used for distinct areas. I restrict this term to those parts lying between the Vertex above and the Profrons below. They have been referred to, not necessarily with the same limitations, as the Optica frontis by Desvoidy (10); the Frontal Orbits or Orbita frontalis by Loew (17) (Loew perhaps intended to use the general term Orbit in a more restricted sense as applying to a slightly differentiated narrower area immediately adjoining the eyes), Osten-Sacken (16) and Williston (15); Orbitos supèriores by Pandellé (19); Geno vertical plates by Hough (9); Parafrontals by Aldrich (14); Orbits by Lundbeck (28); Wangenscheitelplatten by German authors, including Brauer (3), who also uses Periorbita apparently in the same sense; Parafrontalia by Bezzi (25, etc.); Periorbiten by Hendel (20). They form part of the Vertex of Peterson (12), and some authors appear to have regarded them as part of the Genae (see Desvoidy (10) and Hough (9)).

The frontal bristles already referred to (Fig. I, 5) are on the edge of the Frontorbita next to the Frontalia, and there are sometimes one or more additional rows parallel or a number disposed more or less irregularly. In addition to the above there are some important bristles known as the Fronto-orbital (Fig. I, 7) which are very frequently referred to; these are situated near to the eye-margins, and are usually large and strong and curved outwards and downwards over the eyes. They may occur in both sexes, and rarely in the male sex only; but usually they are missing in the males and are found in the females only, and constitute a useful secondary sexual character; two on each orbit is the most frequent number, but there may be one only, or several. Villeneuve (18) has called attention to another bristle sometimes to be found situated above the Fronto-orbitals and between them and the Verticals, which is usually curved upwards or backwards and which he calls the Praevertical. He differentiates it from the topmost Frontals, which are frequently extra strong and curved backwards (Fig. I, 6) unlike the rest of the Frontals, but admits that it may possibly be only one of those displaced; and I think it will be difficult to maintain a difference between the two sets of bristles. Hough (9) distinguished between the lower Frontals curved inwards and forwards and these stronger upper recurved ones, and called the former " transfrontal " and the latter " ascending frontal." He does not seem to have recognised the Praeverticals as in any way distinct from the others. In the circumstances I have elected to use the term Praevertical for all the upper strong recurved bristles whether in a direct line with the Frontals or more in a line with the Fronto-orbitals. Bezzi (25) seems to have employed the term in this sense.

Frontal Triangle, Vertical Triangle. In the males of some species the eyes nearly meet across the Frons; that is to say, the Frons practically disappears except for a triangular portion above and another below. These are sometimes referred to as the Frontal Triangle and the Vertical Triangle (Loew (17) and Williston (15)), although the front one is, of course, part of the Frons and sufficiently indicated by that term, and the upper one consists of the Vertex and Ocellarium and doubtfully needs any other term.

Profrons (Figs. I and II, F). I propose this term for the prominence between the Frons and the Facies, the angle so to speak formed by the meeting of these two

planes, which sometimes projects forwards very noticeably and is a conspicuous feature in the general form of the head, and one to which it is often necessary to refer; it has been called the Frontal Prominence and Frontal Angle, but has generally been referred to as the frons or front or stirne, all terms which have other and distinct and different meanings, so that it is really inaccurate to speak of the "frons" as being "prominent" or otherwise, as is commonly done. Hendel (20) called it the Stirnwinkel.

Facies or **Face** (Figs. I and II, F to M). A general term usually somewhat loosely applied to the area below the profrons and between the eyes. Its lower boundaries have not been clearly defined, but might be regarded as the Peristoma in the centre and the upper frontal margins of the Medianae at the sides. It is the Untergesicht of German authors.

Ptilinoraph or **Frontal Suture** (Figs. I and II, J). The upper part of this Suture has already been referred to under Interfrontalia. A little above the antennae it forks and the two arms come outwards and downwards running around the upper edge of the Lunula (Figs. I and II, E) and down the Facies just outside the Facialia (Figs. I and II, G), terminating in marked depressions at points near to the Medianae. It is through this Suture at its central point above the Lunula that the Ptilinum is exserted. Peterson (12) does not seem to regard the Frontal Suture as homologous with the Epicranial Suture of the Nematocera and other sections of the Diptera; indeed he distinctly states that no Epicranial Suture occurs in any Dipteron possessing a Frontal Suture or Ptilinum. It is difficult, however, to resist the conclusion that the two Sutures are related, especially as the upper portion or stem seems to be the same for both. In the TACHINIDAE it is only the lower or forked portion which is conspicuous, and as this is the part connected with the Ptilinum, Prof. Murray suggested for it the term Ptilinoraph. It is the Bogennaht of German authors; Fissura frontalis of Loew (17), and Frontal Fissure of Osten-Sacken (16), but has usually been referred to as the Frontal or Facial Suture. Hitherto it has not been much used for taxonomic purposes, but I am inclined to think that its relations with the Mediana, Vibrissaria, etc., may be worth studying.

Ptilinope (Fig. II, V). This term, which was another of those kindly suggested to me by Prof. Gilbert Murray, seems to be appropriate for the depressions which terminate the arms of the Ptilinoraph below. These depressions, judging from Peterson (12), may be of morphological significance. Brauer and von Bergenstamm (3) call attention to them, using, however, no other term but Grube, but adding that they represent the Bogengrube, Gesichtseindruck and Quereindruck of other German authors. There seems confusion, however, in the use of these German words which may also be taken sometimes as applying to the Medianae, or perhaps the whole Ptilinoraph.

Fronto-Clypeus. The whole area within the fork of the Ptilinoraph or Frontal Suture, bounded below by the Epistomal edge. This term is used by Peterson (12) in a morphological sense, and may be said to include the Interfacialia as a part of itself, as the Interfacialia in turn includes the Foveae. It includes the lunula and constitutes a more definite morphological entity than either Interfacialia or Foveae. It is a term in little use and scarcely seems required save for completeness. Lundbeck (28) uses the term Epistoma and defines it as the area between the arms of the suture, so that in that sense it would be the equivalent of the Fronto-Clypeus as here defined.

Lunula (Figs. I and II, E). A crescentic piece lying immediately above the antennal bases and bounded above by the fork of the Frontal Suture: it is the Lunula frontalis of Loew (17); Frontal Lunule of Williston (15). It seems at times to have been extended to mean the whole surround of the bases of the antennae, in which case it would appear to be equivalent to the Antennal Sclerites of Peterson (12). Desvoidy referred to that portion of the Cranium which carries the Antennae as the Antennaria (10), which again would seem to be the same as the Antennal Sclerites.

Facialia (Figs. I and II, G). Two ridges separating the central portion of the Facies from the sides. They start from the neighbourhood of the Lunula and curving outwards and downwards form an arched surround to that part of the Facies in which the Antennae arise and into which they are usually more or less sunk. They appear to follow the line of the Ptilinoraph, which runs just outside the Facialia and may be regarded as their outside boundary. They do not always quite reach the Peristoma, and indeed in a few cases do not nearly reach it. The term is one of Desvoidy's (10), and there is no real alternative, although they have often been referred to as Facial ridges (Coquillett 21), Vibrissal ridges (Hough 9), and Vibrissenleisten, and Rondani (2) called them Carinae facialis. They terminate in the Vibrissaria (q.v.), and often bear bristles, which sometimes are well developed along the whole length, but more frequently consist of only a few small ones just above the Vibrissaria, and are known as the Facial bristles or setae.

Vibrissaria (Figs. I and II, L). The callus-like terminations of the Facialia, at or a little above the Peristoma. They usually carry one long strong bristle on each, which curve inwards and cross one another and which are known as the Vibrissae (Fig. I, 8), and with them a few small bristles as well. They have usually been referred to as the Vibrissal Angles or Facial Angles, or by the Germans as Vibrissenecken, and I propose the single word term Vibrissaria, which seems obvious in its meaning and sufficiently close to tradition.

Interfacialia (Fig. I, U). That portion of the Facies lying between the Facialia and extending from the Antennal bases above to the Peristoma below. It constitutes a portion only of the Fronto-clypeus and is contained within the same; the Foveae again being similarly contained within the Interfacialia. In writing of this part of the head various terms have been employed, but almost always without definition, so that it is usually uncertain how much of the face is intended. It seems desirable therefore that separate and clearly defined terms shall be used, and I therefore propose Interfacialia, a word suggested by my friend Mr. Collin, and obviously descriptive for the area which is, I think, sufficiently indicated above. Brauer and von Bergenstamm (3, 1889, p. 4) pointed out the distinctions between the three areas, using the German word Gesichtschild for the larger one, which they defined as consisting of the Clypeus + Vibrissenleisten (= Facialia) + Antennae, and which therefore corresponds with the Fronto-clypeus as defined above; Gesichtsgrube for what is here called Interfacialia, and which is clearly defined by them as being bounded by the Facialia, and containing within it their Fühlergrube. Their Clypeus is apparently synonymous with their Gesichtsgrube; but Clypeus seems to be an unsuitable term, as it appears to be considered that the true Clypeus is a small sclerite below the Peristoma and usually inconspicuous (Loew, 17, Desvoidy, 10); the term has been used by various other writers, including Villeneuve (18) and Hendel (20). Another similarly inappropriate term is Epistoma, which was employed by Pandellé (19) amongst others. Desvoidy (10) remarks that Hypostoma had been so used by German authors, but incorrectly. Desvoidy himself, whilst appreciating the true character of the Foveae, had no term for what is here called Interfacialia and made the term Foveae do for both; and Antennal Foveae or Fossae seem to have been similarly loosely applied by others. The German word Gesichtschild so frequently met with in Schiner (1) and others cannot be regarded as being used exactly in the same sense as by Brauer and von Bergenstamm, but is generally of uncertain application, and Fühlergrube and Gesichtsgrube are similarly loosely employed. Séguy (13) calls it the Partie Mediane, and says it is the Clypeus of Villeneuve; Hough (9) uses Facial Fossa, and Coquillett (21) writes of it as the Facial or Median Depression.

Foveae. The actual grooves or fossae in which the antennae lie, which as above stated form a part of, and are contained within, the Interfacialia. Most frequently the two grooves are united and form one large hollow in which the antennae are situated, and the hollow may be so large as to occupy practically the whole area of the Interfacialia. In some species, in the DEXIINAE particularly, the

grooves are separate and distinct, with a narrow ridge running between them, this ridge being known as the **Carina** or merely as the Facial Ridge (Loew, 17).

Genae (Figs. I and II, H). The sides of the Facies, those parts lying between the eyes and the Ptilinoraph or Frontal Suture, extending from the termination of the Frons at the Profontal angle, to the upper edges of the Medianae. One of the parts most needing clear definition and agreement, for in a most uncertain and confusing manner Genae and/or a number of alternative terms have been used for an area of variable extent and importance; and whilst the majority of writers have probably had in mind one much the same as that defined above, yet it is rarely if ever certain what limits are intended to be set by any one author, as, for example, whether or not the Medianae are to be regarded as being included; and, as mentioned below, there has even been confusion with the Buccae at times.

Loew (17) used Genae for what are here called the Buccae, and apparently called our Genae the Facial Orbits, though there is a little uncertainty here, and it is possible that he meant to restrict the term Orbits to slightly differentiated areas sometimes to be detected adjoining the eye-margins, in which case he may have intended his term Genae to have a more extended application. Peterson (12) also applies the name Genae to our Buccae, treating our Genae as parts of his Vertex. Hough (9) seems to have been almost alone in attempting to set exact limits to this part, and his definition is in accordance with mine. Perhaps the very uncertainties referred to have led authors to propose so many alternatives, but it seems best to retain and define the term which is one of the oldest employed in descriptive dipterology and can claim the sanctity of priority and tradition.

They are the Gênes of French authors, and the Wangen of the Germans (Schiner, 1, etc.). The latter use Backen for our Buccae, and according to dictionaries Wangen and Backen have almost the same meaning in English, and apparently either may be translated equally correctly as cheeks or jowls. Verrall (23) adopted the more familiar word cheeks for the Genae, and applied jowls to our Buccae, and Lundbeck (28) has followed him. Williston (15) gives cheeks or jowls merely as alternatives for what he defines as "the space back of the face and below the eyes," by which he evidently means our Buccae, and, following Loew, speaks of our Genae as the Facial Orbits; he is followed by Coquillett (21) amongst others. Desvoidy (10) included the Genae in what he called the Optica Faciei; Aldrich (14) called them Parafacials; Bezzi (25, etc.) Parafacialia, and Pandellé (19) Sous-orbites.

Amongst those who appear to have used Genae or Gênes in our sense are Hough (9), Séguy (13), Villeneuve (22) (Séguy quotes Villeneuve as his authority for the adoption of the term), Brauer and von Bergenstamm (3) and Rondani (2).

There is frequently a row of strong bristles on the Genae, often more or less continuous with the Frontal series, and they are referred to as the Genal setae; in other cases there will be hairs or irregularly disposed short setae in greater or less numbers.

Epistoma (Figs. I and II, M). I have retained this much-misused term for the lowest part of the Interfacialia, that portion which is little more than the ridge at the meeting place of the Interfacialia and Peristoma. It is of great taxonomic importance in its relation to the Vibrissaria, etc., and also in its exact form. It occupies the third angle in the outline of the head as seen in profile, namely that at which the Facies or front plane meets the Succiput or lower plane, and may be regarded as dispensing with the need of a special term for the angle. Desvoidy (10) appears to have used the term in exactly the same sense. It is the Mundrand of German authors, and Brauer and von Bergenstamm (3) use Margo Oris apparently with this meaning. Séguy (13) seems to regard the Epistoma as something distinct from the Interfacialia, which apparently he regards as terminating somewhere above the Peristomal edge. Williston (15) seems to consider Epistoma and Peristoma as being synonymous terms equally applicable to this part; on the

other hand, the German word Mundrand seems used both for the Epistoma and our Peristoma with insufficient discrimination.

Clypeus. The true Clypeus appears in this family to be represented by a very small sclerite to be found below the Epistoma and practically within the Stoma itself. (See Desvoidy (10) and Loew (17).) Séguy (13), however, seems to hold different views and to regard the Clypeus as being fused with the Interfacialia, and appears to treat Clypeus and Epistoma as synonymous terms; and Peterson (12), similarly, seems to regard the true Clypeus as a part of his Fronto-clypeus, and the small sclerite below the Peristoma as the Torma. The point is an obscure one and unimportant from a taxonomic point of view.

Succiput (Fig. II, M to T). Just as the upper part of the head has a general name (Frons), and the forepart is the Facies, and the whole hinder aspect is the Occiput, so it seemed to me that the underside as a whole needed a general term as well, and Prof. Gilbert Murray suggested this word which fits in well with the use of the similar word Occiput. It may be defined as extending from eye to eye, limited in front by the Epistoma and the upper frontal edges of the Medianae, behind by the Occipital edge, and on the Postorbita perhaps by the suture which in its continuation opens out into the Mediana.

Lateralia (Figs. I and II, P). The whole of the areas lying between the eyes and the Peristoma and extending from the Occipital edge at the back to the Facialia and upper margin of the Medianae in front. They are the larger areas containing the Buccae and Medianae. The term is one of Desvoidy's (10), somewhat arbitrarily applied as explained under Buccae (q.v.).

Medianae (Figs. I and II, N). A triangularly shaped area on each side between the Genae and the Buccae, distinguished by differences in texture and colour from its surroundings, usually being more or less rufous. It extends from the Occipital region running immediately below the eyes, where it is narrow and often inconspicuous, and thence across the Facies below the Genae to the Facialia. On the Facies it widens out considerably and assumes its triangular shape, but varies considerably in this respect; sometimes it becomes very wide and will include the Ptilinope within its area, and its lower edge may run into the Peristomal edge well away from the Vibrissaria. It seems likely that it represents part of a suture or membranous area between two sclerites. The term is one of Desvoidy's (10), and there is no alternative; but the Germans perhaps sometimes intend to speak of it when using such words as Bogengrube, Gesichtseindruck and Quereindruck, the exact application of which is uncertain; and it has also been referred to as the Transverse Impression (Hough, 9). Lundbeck (28) calls it the "Intermediate Triangle."

Buccae (Figs. I and II, P). See Lateralia. The Buccae are the more restricted areas consisting of the Lateralia less the Medianae. As a rule the Medianae are not only distinguished from them by their peculiar texture and colouring, but they bear neither bristles nor distinct hairs, whilst the Buccae are characterised by marked hairiness or bristliness. These parts have suffered like others from the uncertain and variable application of terms, and in part the confusion resulting has been dealt with in the notes on the Genae.

The term Buccae was proposed by Hough (9) and defined by him in accordance with the definition given above; and I have adopted his suggestion, though somewhat arbitrarily as Desvoidy (10) had previously proposed Lateralia, a good word which of course has the claim of priority. That term, however, has scarcely ever been used, and, as its application was not very certain, I have elected, in reviving it, to apply it to the larger area as previously described and use Hough's term here in Hough's sense exactly.

They are the Backen of German authors (see Genae); Verrall (23) called them Jowls, and Lundbeck (28) follows him; Williston (15) gives Cheeks or Jowls, which is confusing, and Coquillett (21) used Cheeks; Pandellé (19) and most French writers call them Joues. Peristoma is another of the old terms which has been applied

very variously, and several authors seem to have included the Buccae in the area covered by it, Rondani (2), Séguy (13), Brauer and von Bergenstamm (3) amongst them, and Bezzi (25) uses Peristomalia similarly.

Aldrich (14) followed Hough in using the word Buccae, but altered the definition, extending the area to the eye-margin, thus including the narrow intervening portion of the Medianae. This would make his Buccae not quite agree with either our Lateralia or our Buccae.

Loew's (17) Genae seem to be coincident with our Buccae, and he appears to use Inferior Orbits for the narrow strips of the Medianae below the eyes (see Front-orbita), but I am not sure that I understand him regarding this last point.

Peterson (12) included this part with our Genae, etc., as parts of his Vertex, a general term which he uses for a large part of the exoskeleton of the head, but also like Loew he uses Genae for the parts dealt with here, our Buccae, defining them as " the regions of the Vertex ventrad and mesad of the compound eyes."

As mentioned above, the Buccae are usually more or less setigerous or at least bear long hairs, but the bristles have not at present been found to be of much taxonomic value.

Peristoma (Figs. I and II, O). The edge immediately surrounding the Stoma or mouth-opening. As stated above, this term has been used by Rondani (2) and others for an extended area including the Buccae, and Desvoidy (10) used it for the buccal cavity, but it seems fitter to restrict it to the actual ridge enclosing the hollow of the Stoma, which would apparently be the meaning of the word itself. In effect therefore, when looking at the head in profile, the Peristoma is coincident with the lower margin. Wingate (27) uses the term apparently in the same sense. It is the Mundrand of German authors, who, however, use that term not only for the whole Peristoma but also in particular for that portion of it which is here dealt with as the Epistoma. Loew (17) seems to use the term in our sense exactly, and Osten-Sacken (16) appears to follow him. Bezzi's Peristomalia (25) would include this part, but seems applied to a larger area altogether. There are usually some strong setae in a series along the ridge, but they are not much referred to.

Stoma. The mouth-opening or buccal cavity occupying practically the whole underside of the head. It is the Russelgrube of German authors, Brauer and von Bergenstamm (3), etc., and Desvoidy (10) called it the Peristoma. Not often specifically mentioned, and in terminology does not seem to have been clearly distinguished from the Peristoma, which word, however, surely means that which surrounds the mouth.

Postbuccae (Fig. II, T). As seen in profile the Muscid head presents practically four sides or planes and four angles; one can speak of the Vertex, the Profrons and the Epistoma, and occasionally one seems to need to refer to the fourth angle, the lower hind one, for which Postbuccae seems suitable.

Postorbita (Fig. II, R). The narrow space behind the eyes between the eye-margins and the Occipital edge, extending from the Vertex above to the Mediana below. They are the Posterior Orbits of Loew (17) and others, and apparently are included in the Postgenae of Peterson (12). On or immediately behind the actual Occipital edge is usually a closely set fringe of fine short hairs forming the Postorbital Cilia or Fringe.

Occiput (Fig. II, S). The back or caudal aspect of the head. I have followed Loew (17) in using this term for the whole hinder part of the head which faces the thorax, although Peterson (12) and others use it for the upper portion or part of the upper portion only. From the point of view of the systematist this part of the head has received so little attention that it must be left for the present, though it will doubtless repay more careful study. Moreover, even from the point of view of the morphologist it does not seem to be well understood, and such terms as I have come across seem to be very ill-defined. There are what seem like four or more sutures radiating in pairs from the Occipital Foramen in the insects with which we are chiefly concerned, dividing the whole area into four main parts, of which

the upper one between the Vertex and the Foramen appears to be the Epicephalon of some authors, and to have had the term Occiput restricted to it by others. Peterson (12), however, defines the Occiput as all that portion of the hinder aspect above an imaginary transverse line drawn through the Foramen. The two side pieces

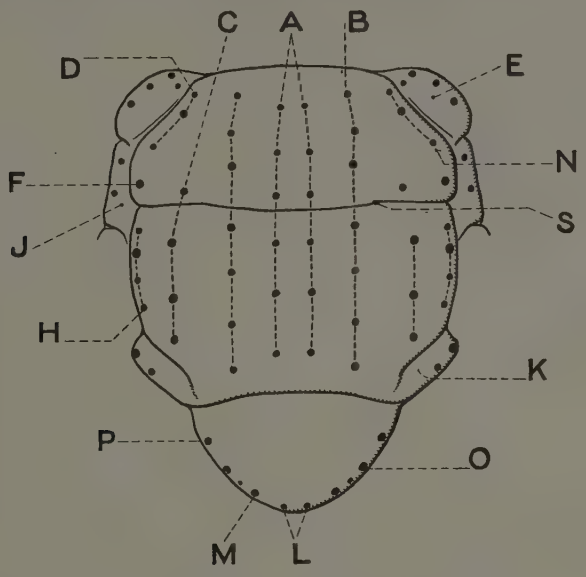

Fig. III.—Thorax.
Showing the arrangement, etc., of the bristles.

A. Acrostichals.
B. Dorso-centrals.
C. Intra-alars.
(The bristles of the above three series are found both in front and behind the Median Transverse Suture (S); those in front being called the Praesutural and those behind the Postsutural (thus "Praesutural Acrostichals"). It is necessary to distinguish carefully between the two portions, as from a taxonomic point of view they are separate entities, and it is better always to use the distinctive adjective; frequently, however, in the writings of entomologists one finds them mentioned without, and especially do we come across "Dorso-centrals" or merely D.C. (thus 3 D.C. or 4 D.C.), and in such cases the postsutural bristles are indicated.)
D. Posthumerals. Those behind the Humerus.
E. Humerals. Those on the Humerus.
F. Praesutural.
(The homologies of this bristle are doubtful, and I have merely followed Girschner in the use of the term.)
H. Supra-alars.
(The above-named Praesutural bristle is so placed that one might perhaps call it the Praesutural supra-alar.)
J. Notopleurals.
K. Post-alars.
L. Apical Scutellars.
M. Subapical Scutellars.
O. Lateral Scutellars, a term often used more widely to include the Basals.
P. Basal Scutellars.
(The above L, M, O, P, collectively are the Marginal scutellary bristles. In addition there are frequently one or more pairs of Discal ones, usually one pair just in front of the Apical ones.)
N. The outer post humeral.
S. The Transverse Suture.

lying between the upper or lateral pair of sutures and the lower pair appear to be the Post-genae, though Peterson restricts that term to the portions below the central transverse line referred to above, excluding the area between the lower pair of sutures. The latter area between the lower pair of sutures appears to be the metacephalon of some (Aldrich, 14). Loew (17) used Cervex for the upper portion or

part, and Desvoidy (10) suggested the term Cerebrale for the same or a similar part and was followed by Hendel (20). The upper pair of sutures seem to me to be continuous with the Medianae. Aldrich (14) points out that the lower pair which he calls the Metacephalic Sutures continue perceptibly " to the edge of the mouth, cutting off the back part of the Buccae," and says that the hairs on the two sides of these lines are often different and provide aids for distinguishing the females of the genus *Sarcophaga*.

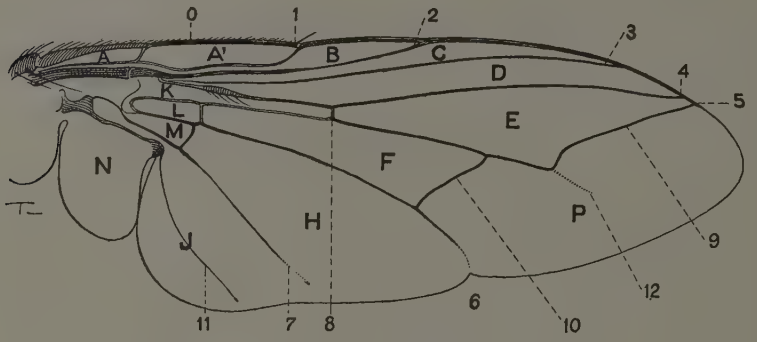

Fig. IV.—Wing.

Veins.

0. Costa.
1. Mediastinal or auxiliary
2. Subcostal or first longitudinal.
3. Radial or second longitudinal.
4. Cubital or third longitudinal.
5. Discal or fourth longitudinal.
6. Postical or fifth longitudinal.
7. Anal or sixth longitudinal.
8. Discal or median or middle cross-vein; usually in this family called the Inner or Small cross-vein.
9. Subapical cross-vein or upper marginal; in this family often called the Hind-marginal. Really this is the apical portion of the Discal or fourth longitudinal, a fact which is obvious in this family in which it is of much taxonomic importance.
10. Postical or lower marginal cross-vein; usually in this family called the Hinder cross-vein.
11. Axillary vein.
12. Cubital appendage of the fourth longitudinal vein; really all that is left of the lower arm of this vein.

Cells.

A. Basal costal or mediastinal.
A'. Second costal or mediastinal.
B. Subcostal.
C. Marginal.
D. Cubital or Submarginal.
E. First Posterior or Subapical.
F. Discal or second Posterior.
H. Third Posterior.
J. Axillary.
K. Upper or first basal or radical.
L. Middle or second basal or radical.
M. Lower or third basal or radical.
N. Alula.
P. Hind-marginal, a term of convenience only in this family.

Thorax. (Text-fig. III.)

The nomenclature of the bristles of the Thorax is according to Girschner. For details see the explanation of the Text-figure.

Curran (29) proposed a new term, sublaterals, for the praesutural intra-alars on the ground of the cumbersomeness of the latter term. The latter, however, having all the claims of priority and being generally accepted should not be disturbed. Confusion is added by his including with them some of the posthumerals.

Wings. (Text-fig. IV.)

In general the nomenclature adopted for the Veins and Cells of the Wings is according to Verrall (23). For details see the explanation of Text-figure.

III. Key to Subfamilies and Genera.

The Tachinidae are separated from all other Muscidae by the possession of a short row of bristles on the hypopleura, just in front of the spiracle. Some of the Anthomyidae such as *Pyrellia* resemble some of the Calliphorinae section very closely, but examination of the hypopleurae will settle any doubts.

1. The second ventral plate or sternite (the apparent first) free and large, its edges usually overlapping the edges of the dorsal plate or tergite, or if not actually overlapping at least wide, free and not itself overlapped. (In a few species belonging to the small group of genera including *Ptilocerina*, sometimes separated into a subfamily and called Rhinophorinae, the females do not show this character of the second ventral plate very well, though it is conspicuous enough in the males. These genera will also be found referred to in other parts of the table accordingly) . . (2)

   The second ventral plate more or less overlaid by the edges of the corresponding dorsal plate, which are sometimes produced so far as to meet over the ventral plate and almost hide it . . . . . (3)

   Tergites and sternites not meeting but separated by a greater or less width of outstretched membrane, which more or less surrounds the rather small sternites. (This separates off the Phasiinae, which are characterised by very slight development of the chaetotaxy, and usually the interfacialia in its lower half is domed prominently between the vibrissaria) . . . . . **PHASIINAE.** (194)

2. The outer post-humeral bristle placed further outwards from the central line of the dorsum than the praesutural (supra-alar) bristle. (This is the one definite character which separates off all the Calliphorinae, which are, however, generally distinguished by weak development of the macrochaetae, which are usually lacking on the dorsum of the abdomen and are sometimes so slightly developed as to make even the character quoted above rather difficult to observe; they usually have long ciliations on the arista (*i.e.* are plumose), and are frequently of a more or less metallic green or blue colour.) (Some of the Anthomyidae resemble species of this group very closely, especially *Pyrellia* and its allies, but no doubt should remain after examination of the hypopleurae) **CALLIPHORINAE.** (184)

   The outer post-humeral bristle placed nearer the central line of the dorsum than the praesutural (supra-alar) bristle. (The species of this group are characterised by well-developed chaetotaxy; colouring more or less of the normal grey kind typical of the Tachinidae generally; the arista is often ciliated, but the ciliations are never so long as in the majority of the Calliphorinae, and frequently are confined to the base of the arista, the apical portion being bare.) **SARCOPHAGINAE** and **RHINOPHORINAE.** (155)

3. Interfacialia with a keel; that is to say, a distinct ridge is to be found down the middle of the facies arising between the bases of the antennae and forming two foveae or grooves in which the antennae lie more or less deeply. (This separates off the true or typical Dexiinae, usually characterised by long legs, longish abdomen and distinctly plumose arista, with well-developed macrochaetae. The ciliations of the arista are always continued to the tip) . . . . . **DEXIINAE.** 145)

   Face without any keel . . . . . (4)

4. Venation unique amongst British TACHINIDAE; the discal or 4th longitudinal vein not turned up at all towards the cubital or 3rd longitudinal, but continued to the margin nearly parallel with same (but note *Morinia* with but a slight curve and *Roeselia*, *Phytomyptera* and some species of *Actia* with the apical or upturned portion missing altogether.) 137. **CINOCHIRA.**

Venation as usual with a more or less marked forward bending of the discal vein towards the cubital (but note the cases referred to above, where apical portion fails) . . . . . (5)

5. Head unique; the vibrissaria high up the face, about halfway between the lunula and the lower edge of the epistoma, and meeting one another across the interfacialia . . . . . 97. **DEXIOSOMA.**

Head otherwise formed, vibrissaria never so high up . . . . . (6) **TACHININAE** (mainly).

6.*Second joint of the antennae lengthened so that it is longer than the third; whole antennae never very short. (Large flies, including the biggest species in the family, and some of the largest of Diptera, mostly very stout and robust-looking and with very strongly developed macrochaetae) (7)

Second joint not conspicuously lengthened and usually much shorter than the third. Only in some species with very short antennae are joints about equal . . . . . (10)

7. Species with hairy eyes. (This separates off a few species of *Ernestia* sens. lat. which have the two antennal joints about equal, but which do not rightly belong to this group) . . . . . 6. **ERNESTIA** p.p.

Species with bare eyes . . . . . (8)

8. Edges of tergites widely separated beneath; genae with downy hairs but no strong bristles . . . . . (9)

Edges of tergites meet or nearly meet beneath; genae with some strong bristles . . . . . 3. **PELETERIA.**

9. Abdomen clothed with strong bristles but with no fur-like hair 2. **ECHINOMYIA.**

Abdomen clothed with fur-like hair with some stronger bristles 1. **SERVILLIA.**

10. Epistoma produced between and in front of the vibrissaria so as to appear nose-like or beak-like in form as seen in profile. (See Pls. IX and X, figs. 1, 8 and 10) . . . . . (11)

Epistoma not so produced, when the head is viewed from the side the edge of the epistoma, being nearly in a line with the vibrissaria, is not perceived or not sufficiently so for it to be regarded as beak-like . . (30)

11. The vibrissaria are above the level of the peristoma; the beak-like projection of the epistoma is therefore definitely below them. (Pl. IX, fig. 1) . . . . . (12)

The vibrissaria at or but little above the peristomal edge and on a level with the lower margin of the epistoma, so that the projection of the epistoma is therefore actually between them and in a line with them. (Pl. X, figs. 8 and 10) . . . . . (20)

The lower part of the interfacialia very much domed and projecting, vibrissaria high above the peristoma, but the projecting domed part extends still higher . . . . . **PHASIINAE** (p.p.) 139. **XYSTA.**

12. Large robust species with stout abdomens . . . . . (13)

Smaller species with longer, slenderer abdomens . . . . . (15)

13. Palpi small and undeveloped, almost lacking occasionally . . 4. **MICROPALPUS.**

Palpi fully developed . . . . . (14)

* Throughout this paper, when speaking of the relative lengths of the joints of the antennae, I have in mind the same as seen in side view and measured along a central line. Seen from in front, the second joint would usually appear longer and the third shorter in proportion owing to the form of the second joint, which is generally somewhat produced in front.

14. Genae clothed with distinct hairs . . . . . 7. **Meriania.**
Genae not clothed with hairs but with a few strong and conspicuous bristles . . . . . 114. **Helicobosca.**
Genae with neither bristles nor distinct hairs . . . . . 6. **Ernestia.**
15. Genae clothed with numerous short setose hairs on the upper portion (wide genae and lateralia, narrow frons) . . . . 101. **Rhinomorinia.**
Genae furnished with neither hairs nor bristles . . . . . (16)
16. Discal vein bent forwards sharply with traces of an appendage at the angle (17)
Discal vein curved forwards gently so that the bend is rounded and not angular, and the apical portion convex outwardly . . . . . (18)
17. Large species with four D.C. bristles; hinder cross-vein meets the 4th longitudinal nearer to the bending of the same than to the discal cross-vein. Size over 11mm. in length over all.
37. **Parasetigena silvestris,** R.-D.
Smaller species with three D.C. bristles; hinder cross-vein meeting the 4th longitudinal midway between the bending and the discal cross-vein. Size under 9 mm. in length . . . . . 44. **Stomatomyia.**
18. Facialia with ciliations reaching nearly to the level of the bases of the aristae . . . . . 45. **Perichaeta.**
Facialia bare excepting for a few small bristles immediately above the vibrissaria . . . . . (19)
19. Shiny black species, with little tomentum; very setose; abdomen short and oval . . . . . 76. **Minella.**
Dark species, but with much whitish tomentum; not specially setose, but with one pair strong discals on each of the central segments; abdomen long and narrow . . . . . 84. **Rhynchista.**
Yellowish species, with bright yellow tomentum; macrochaetae greatly reduced; abdomen short and oval . . . . . 140. **Clytiomyia.**
20. Eyes distinctly clothed with hairs . . . . . 85. **Eriothrix.**
Eyes without any obvious hairiness . . . . . (22)
22. Proboscis lengthened and projecting prominently . . . . 82. **Aphria.**
Proboscis of normal length, etc. . . . . (23)
23. Abdomen constricted in basal portion . . . . . (24)
Abdomen of normal form . . . . . (25)
24. First posterior wing-cell closed and stalked; that is to say, the 4th longitudinal vein reaches the 3rd before its tip. . . . . 87. **Ocyptera.**
First posterior wing-cell open . . . . . 86. **Lophosia.**
25.*Abdominal segments bearing discal as well as hind-marginal macrochaetae on 2nd and 3rd as well as on the 4th . . . . . (26)
Abdominal segments bearing no discal macrochaetae on the 2nd and usually none on the 3rd . . . . . (28)
26. Second joint of arista distinctly lengthened, at least twice as long as wide.
79. **Demoticus.**
Second joint of arista short as usual . . . . . (27)
27. Cubital or 3rd longitudinal vein armed with a few bristles towards the base only . . . . . 80. **Rhinotachina.**
Subcostal, cubital and postical or 1st, 3rd and 5th longitudinal veins armed with bristles for the greater part of their length . . 81. **Bithia.**
28. First posterior cell closed and stalked 109. **Rhinophora (Clista) lepida,** Mg.
First posterior cell open at tip; that is, 3rd and 4th longitudinal veins not meeting . . . . . (29)

* Throughout this paper the segments of the abdomen are numbered as seen. Morphologically the first visible segment is generally considered to be the true second, and Lundbeck (28) speaks of it as such throughout, and numbers the others accordingly. It is more general, however, to speak of the first visible segment as the first and the others accordingly, and that is the course pursued here.

29. Frontal bristles not descending below the level of the base of antennae. 93. **Atropidomyia.**
Frontal bristles descend as low as level of end of 2nd joint of antennae. 83. **Myiobia.**
30. Head swollen-looking, antennae more or less sunk into the face. (Pl. X, fig. 11) . . . . . (31)
Head normal, not swollen-looking . . . . . (34)
31. Genae armed with bristles . . . . . 50. **Gonia.**
Genae without bristles, though they may be distinctly hairy . . . . (32)
32. Apical pair of bristles present on the scutellum; 2nd aristal joint markedly lengthened . . . . . 47. **Brachychaeta.**
No apical pair of bristles present on the scutellum; 2nd aristal joint short (33)
33. Genae clothed with distinct hairs . . . . **Baumhaueria** (non-British).
Genae bare . . . . . 48. **Histochaeta.**
34. Facies shortened; underside of head more or less long and sloping away from vibrissaria; profrons prominent; vibrissaria practically level with the lower edge of epistoma; head generally appearing long in comparison with height, or at least squarish. (See Pls. IX and X, figs. 6 and 7) . (35)
Facies shortened; underside of head short; profrons not prominent, and lower edge of epistoma rather receding, so that head seen in profile has a more or less semicircular appearance; vibrissaria about level with lower edge of epistoma. (See Pls. IX and X, figs 5 and 9) . . . . (48)
Facies shortened; profrons prominent; underside not long; viewed in profile front appears straight; the facies shortened by the vibrissaria being situated well above the edge of the peristoma. (See Pl. IX, fig. 3) . . . . . (55)
Facies not shortened, but generally of the typical Tachinid type. (See Pl. IX, fig. 2.) Vibrissaria usually at or but little above the level of the lower edge of the epistoma; epistoma rarely produced, and, if it is, then the vibrissaria are carried forward with it so that the lower edge of the epistoma never projects beak-like; profrons always prominent . (62)
35. Large stout species with distinct praesutural intra-alar macrochaetae (alulae bearing conspicuous hairs) . . . . . 11. **Nemoraea.**
Smaller more slender species with no praesutural intra-alar macrochaetae (36)
36. Eyes bare . . . . . (37)
Eyes clothed with distinct hairs . . . . . (43)
37. Genae bare . . . . . (38)
Genae clothed with distinct hairs or bristles . . . . . (39)
38. Arista with distinct ciliation *i.e.* feathered . **Anthracomyia** (non-British).
Arista bare with no distinct ciliations . . . . . 73. **Pelatachina.**
39. Discal or 4th longitudinal vein bent forwards with rounded curve, or at least at a very blunt angle . . . . . (40)
Discal vein bent forward in a more or less sharp angle . . . . . (41)
40. First posterior cell closed at the hind margin, no stalk; abdomen without discal macrochaetae; males with 6th sternite developed into two conspicuous large lapels, also with fronto-orbital setae as in the female sex . . . . . 106. **Frauenfeldia.**
First posterior cell closed and short-stalked; abdomen without discal macrochaetae; males with normally developed 6th sternite and with no fronto-orbital setae . . . . . 105. **Styloneuria.**
First posterior cell open; abdomen with discal macrochaetae; males with normally developed 6th sternite, and possessing fronto-orbital setae . . . . . 89. **Phyllomyia.**
First posterior cell open; bending of discal vein nearly flattened out; abdomen practically without any macrochaetae; females with the 5th segment greatly lengthened and produced anteriorly beneath 135. **Freraea.**

41. Genae with three or four long strong setae . . . . . (42)
Genae with a number of quite short, not very strong, somewhat hair-like bristles . . . . . 108. **PHYTO.**
42. Abdominal segments two and three with discal setae; males without orbital setae . . . . . 104. **PTILOCERINA.**
Abdominal segments two and three without discal setae; males possessing orbital setae . . . . . 103. **STEVENIA.**
43. Genae bare . . . . . (44)
Genae clothed with hairs or bristles . . . . . (47)
44. Species of predominantly yellow colour on abdomen, legs, etc. 77. **HYALURGUS.**
Species otherwise coloured . . . . . (45)
45. Epistoma at its lower edge together with the vibrissaria curved forwards prominently . . . . . 76. **MINELLA.**
Epistoma at its lower edge not produced . . . . . (46)
46. Base of wings conspicuously yellow . . . . . 78. **ZOPHOMYIA.**
Base of wings not conspicuously yellow . . . . 75. **MACQUARTIA** (p.p.)
47. A few hairs on upper part of genae only 47A
Genae armed with distinct bristles . . . . . 59. **BLEPHAROMYIA.**
Genae clothed throughout with numerous hairs, not bristles.
75. **MACQUARTIA** (p.p.)
47A. Shining black species with conspicuous yellow bases to wings. 78. **ZOPHOMYIA.**
Grey-dusted species with no conspicuous yellow colour on wings.
124. **RHAPHIOCHAETA.**
48. Eyes clothed with hairs (*petiolata*, R.-D., and *foeda*, Mg., scarcely show the hairs in the ♀♀) . . . . . 74. **LOEWIA.**
Eyes bare . . . . . (49)
49. Genae clothed with hairs or bristles.
74. **Loewia petiolata,** R.-D., and **foeda,** Mg. ♀♀.
Genae bare . . . . . (51)
51. First posterior wing-cell open at the tip of wing . . . . . (52)
First posterior wing-cell closed and stalked . . . . . (53)
52. Discal or 4th longitudinal vein bent forward in a rounded curve.
117. **MEDORIA.**
Discal vein bent forward angularly . . . . . 90. **THELAIRA.**
53. Stalk of first posterior cell quite short . . . . 74. **LOEWIA** (**FORTISIA**).
Stalk of first posterior cell long, *i.e.* nearly or quite as long as the apical portion of the 4th longitudinal vein . . . . . (54)
54. Arista with ciliations, *i.e.* plumose . . . . . 107. **MELANOPHORA.**
Arista bare . . . . . 102. **PLESINA.**
55. Eyes clothed with hairs . . . . . (56)
Eyes bare . . . . . (57)
56. Facialia with ascending bristles reaching nearly as far as the lowest frontal bristles . . . . . (56A)
Facialia with a few setae near to the vibrissaria only . . 39. **MYSTACELLA.**
56A. Abdomen bearing discal macrochaetae; only three D.C. behind the suture; large prominent genital segments . . . . . 38. **PHOROCERA.**
Abdomen with no discal macrochaetae; four D.C.; genital segments not unusually prominent . . . . . 37. **PARASETIGENA.**
57. Tergites meet or nearly meet ventrally, almost hiding the sternites.
40. **MEIGENIA.**
Tergites do not meet ventrally; edges widely separated, so that sternites are exposed . . . . . (61)
61. Abdomen with discal macrochaetae; dark species with yellow legs. (See 158) . . . . . 91. **REDTENBACHERIA.**
Abdomen without discal macrochaetae; grey species with black legs.
41. **VIVIANIA.**

62. Seen in profile, the head has the lower part of the face curved forwards in such a manner as to give a concave appearance to the facies as a whole. The epistoma, however, does not project beyond the vibrissaria but with them. (See Pl. IX, fig. 4) . . . . . (63)
Head long vertically and straight; underside short and not produced anteriorly . . . . . (66)
63. Edges of tergites widely separated beneath . . . . . (63A)
Edges of tergites meet or are only narrowly separated . . . . . (64)
63A. Genae bare . . . . . 65. **HELOCERA.**
Genae bearing bristles . . . . . (63B)
63B. Genitalia large, chiefly owing to the development of the apical visible sternite, which is produced as two large side plates 106. **FRAUENFELDIA,** ♂.
Genitalia inconspicuous and normal . . . . . 108. **PHYTO,** ♂.
64. Abdomen with discal and marginal macrochaetae on the 2nd and 3rd segments . . . . . (65A)
Abdomen with no discal macrochaetae, at any rate on the 2nd segment (64A)
64A. Genae bare . . . . . 63. **ACTIA.**
Genae bearing bristles . . . . . (64B)
64B. Second aristal joint conspicuously lengthened; 3rd antennal joint in the male very large, and almost as wide as long; in female also large, but width reduced to about half length; narrow genae, with but one row of short bristles . . . . . 62. **STENOPARIA.**
Arista with 2nd joint short as usual; small antennae, 3rd joint only about half as large again as the 2nd; wide genae, irregularly setose . . . (65)
65. Blackish species; antennae and legs quite black; eyes small, and lateralia therefore wide and equal to quite half the eye height . 108. **PHYTO,** ♀.
Fuscous species; some yellow on antennae and legs; eyes larger; lateralia not equal to much more than one-third of eye height. 106. **FRAUENFELDIA,** ♀.
65A. Arista thickened in almost its whole length, becoming abruptly fine near its apex; 1st joint lengthened, 2nd twice the length of the 1st, and 3rd about twice the length of the 2nd; antennae black with enlarged 3rd joint (♂), below being nearly as wide as high, but becoming narrower upwards; 3rd longitudinal vein with two or three long setae at base only. 60. **NEAERA.**
Arista thickened in basal half only; 2nd joint elongated, but only about one-quarter the length of 3rd joint; 3rd joint of antennae not enlarged; 3rd longitudinal wing-vein setose, the setae reaching at least to the discal cross-vein . . . . . 64. **THRYPTOCERA.**
66. Proboscis lengthened and elbowed . . . . . 58. **BUCENTES.**
Proboscis normal . . . . . (67)
67.*Praesutural intra-alar macrochaeta present. (See note below) . . . (68)
Praesutural intra-alar macrochaeta absent or weak and inconspicuous (113)
68. Eyes clothed with hairs . . . . . (69)
Eyes bare (there may be a few very small and inconspicuous hairs visible under a lens) . . . . . (85)
69. Genae bare . . . . . (70)
Genae bearing hairs or bristles . . . . . (83)
70. Facialia bearing ciliation, which extends to above the middle of the face (71)

* This character requires very close observation, and is a little uncertain. In very robust specimens of a species from which the bristle is normally absent, it may occasionally be found sufficiently developed to be misleading, and on the contrary, in weak ill-developed individuals of a species which usually possesses the bristle, it may be found so reduced as to lead to uncertainty. Indeed all chaetal characters are somewhat unreliable owing to much variation. In all cases of doubt the alternative columns should be searched.

Facialia without ciliation, excepting for the usual few bristles near to the vibrissaria . . . . . (75)

71. Discal (4th longitudinal) vein bent in a rounded curve and reaching the wing-margin near the wing-tip . . . . . (72)
Discal vein angularly bent and reaching margin in front of the wing-tip . (73)

72. Two or three strong bristles at fork of 2nd and 3rd longitudinal veins; male with conspicuously projecting genital segments; female normal; a single strong bristle on bucca in front . . . . 32. **Hypochaeta.**
Only very inconspicuous bristles at the fork of 2nd and 3rd longitudinal veins; male without conspicuously projecting genital segments; female with serrate underside to abdomen and sickle-like ovipositor; no special buccal seta . . . . . 35. **Compsilura.**

73. Ciliation on the facialia rarely extending above the middle of the face and not reaching as high as the lowest frontal bristles, and not strong but thin and hair-like . . . . . (74)
Ciliation consisting of long strong bristles extending nearly to the base of antennae . . . . . 36. **Pales.**

74. The pair of bristles at the apex of scutellum bent upwards and forwards. 16. **Phryxe.**
The pair of bristles at the apex of scutellum curved backwards and downwards or failing (but see *Zenillia roseanae*, B.B.) 17. **Zenillia** (p.p.)

75. Possessing one fronto-orbital bristle only on each side in both sexes. (This is the normal condition, but occasionally a second one appears, see therefore below) . . . . . 46. **Monochaeta.**
Either with none or with two or more fronto-orbital bristles . . . . (76)

76. Eyes small, lateralia consequently wide, equal to more than half the height of the eye . . . . . (77)
Eyes large, lateralia therefore narrower and equal to one-quarter of the eye height or less . . . . . (78)

77. Large robust species with no discal abdominal macrochaetae. 11. **Nemoraea.**
Medium-sized species with discal macrochaetae, and covered with yellowish tomentum; legs entirely yellow . . 18. **Phryno vetula,** Mg.
Smaller species with discal macrochaetae; tomentum ashy grey with brown hind margins to segments; legs yellow only on tibiae and tips of femora . . . . . 46. **Monochaeta.**

78. Eyes very large; lateralia therefore reduced to about one-tenth of the eye height . . . . . (79)
Eyes normal, lateralia equal to about one-quarter or one-fifth of the eye height . . . . . (80)

79. Base of antennae inserted at a point about level with the eye middle 14. **Carcelia.**
Base of antennae inserted at a point above the middle of the eye. 19. **Pelmatomyia.**

80. Antennae with the 2nd joint lengthened and equal to more than half the length of the 3rd joint . . . . . 20. **Nemorilla.**
Antennae with the 2nd joint not lengthened, 3rd two and a half times the length of the 2nd, or more . . . . . (81)

81. Facialia with ciliation confined to near neighbourhood of the vibrissae and not at all ascending . . . . . 15. **Exorista.**
Ciliation ascending about half-way up the facialia (a character needing close attention and not always reliable) . . . . . (82)

82. Apical scutellary bristles markedly upright and curved forwards (but see *Zenillia roseanae*, B.B., and perhaps other Zenillias too) . 16. **Phryxe.**
Apical scutellary bristles not markedly upright or curved forward. 17. **Zenillia.**

(These three genera, *Exorista*, *Phryxe*, and *Zenillia*, are so closely

allied that it is difficult to separate the species, most of which are very like one another.)

83. Postical cross-vein slanted very obliquely inwards towards the basal portion of the wing . . . . . 51. **Voria.**
Postical cross-vein not so slanted, normal . . . . . (84)
84. Eyes large and lateralia consequently very narrow; no discal macrochaetae on the abdomen, or only a few irregular ones on the 3rd segment. 13. **Winthemia.**
Eyes not large; lateralia equal to about one-quarter of the eye height in width; abdomen with discal macrochaetae . . . 21. **Epicampocera.**
85. Genae bare excepting for the fronto-orbitals, which descend a little way on to them, and possibly a few fine hairs near these fronto-orbitals . . (86)
Genae clothed with hairs or bristles . . . . . (111)
86. Facialia with ciliation distinctly ascending . . . . . (87)
Facialia with a few bristles near to the vibrissae only . . . . . (99)
87. Abdomen without discal setae . . . . . (89)
Abdomen with discal setae . . . . . (90)
89. Second joint of the arista nearly as long as the 3rd . . . 49. **Germaria.**
Second joint of the arista quite short, normal. 28. **Ptychomyia** vars. **(Prosopodes).**
90. Ciliation on the facialia weak and barely reaching the middle . . . . (91)
Ciliation consisting of strong bristles and extending beyond the middle of the facialia . . . . . (95)
91. Species with yellow legs . . . . . (92)
Species with dark coloured legs . . . . . (93)
92. Species with small thin antennae only reaching half-way down the facies. 91. **Redtenbacheria.**
Species with large strong antennae reaching nearly to the edge of the epistoma . . . . . 55. **Rhacodineura.**
93. Small shining black species almost with no tomentum, just a little on the humeri only; frons in male and female wide, as seen from above about one-quarter wider than a single eye, and both sexes alike with two fronto-orbital setae on each side; the wide fronto-orbits black and shining; female with normal underside; short claws in male and female; facial setae not reaching as far as the middle of the facialia, but well developed . . . . . 70. **Arrhinomyia tragica,** Mg.
Rather larger species, not shining, but grey with much tomentum; males and females also have equally wide frons with fronto-orbital setae alike in both sexes, but frons narrower, barely equal to width of one eye; orbits whitish grey with tomentum; females with serrated undersides, the tergites meeting below in a saw-like ridge . . 25. **Microvibrissina.**
Species with no fronto-orbital setae in the males even when frons is wide; insects not shining but well furnished with tomentum; females with normal undersides, not serrated, excepting in *Lydella nigripes*, Fall., which see . . . . . (94)
94. Arista thickened nearly to the tip; lateralia narrow, being only equal to about one-fifth of the eye height . . . . . 23. **Paraphorocera.**
Arista thickened in basal portion only; lateralia wider, being usually equal to about one-third of eye height . . . . . (94a)
94a. Tarsal claws of the males long . . . . . 24. **Lydella.**
Tarsal claws of the males as short as in the females . . . 23. **Ceromasia.**
95. First posterior wing-cell closed and possessing a long stalk . . . . (95a)
First posterior wing-cell open, or, if closed, with no stalk . . . . . (96)
95a. Male with no fronto-orbital setae; females with 3rd antennal joint less than three times as long as the 2nd, and with no marginal setae on the 1st visible abdominal segment . . . . . 31. **Erynnia.**

Male with orbital setae; female with 3rd antennal joint nearly four times as long as the 2nd, and with strong marginal setae on the 1st visible abdominal segment . . . . . 52. **ANACHAETOPSIS.**

96. Small shining black species with no (*tragica*, Mg.) or very little (*cloacellae*, Kramer) tomentum; frons in male and female wide, as seen from above about one-quarter wider than a single eye, and both sexes alike with two fronto-orbital setae on each side; the wide fronto-orbits black and shining, with no (*tragica*) or but reduced (*cloacellae*) tomentum on them; female with normal underside . . . . . 70. **ARRHINOMYIA.**

Larger species, never black and shining, but well furnished with tomentum; fronto-orbits always whitish grey through dense covering of the tomentum . . . . . (96A)

96A. Third joint of the antennae very long, at least six times as long as the 2nd . . . . . (97)

Third joint of the antennae short, less than three times the length of the 2nd . . . . . 47. **BRACHYCHAETA,** ♀.

Third joint of the antennae of medium length, about four times the length of the 2nd, may be less in the females, but is fully three times then . .(96A)

96A. Arista thickened nearly to its tip; facial vibrissae ascending to the level of the lowest of the frontal bristles; first posterior wing-cell closed and running into margin at a point some distance short of the wing-tip; females with normal undersides . . . . . 29. **STAUROCHAETA.**

Arista thickened at base only; vibrissae not ascending to level of lowest frontal bristles; first posterior wing-cell open and running into margin almost at the wing-tip; female with the underside saw-like, the tergites meeting beneath in a serrate edge . . . 25. **MICROVIBRISSINA.**

97. Eyes small, and lateralia therefore wide and equal to more than half the eye height . . . . . (97A)

Eyes larger, lateralia equal to one-third the eye height or less . . . (98A)

97A. First posterior cell runs into the margin near to the wing-tip 57. **HEBIA.**

First posterior cell runs into the margin distinctly before the wing-tip . (98)

98. Species with three D.C. bristles behind the suture, smaller species, about 6 mm. long . . . . . 47. **BRACHYCHAETA,** ♂.

Species with four D.C.; rather large species, 8 mm. or more. 48. **HISTOCHAETA.**

98A. Larger species with broadly rufous sides to abdomen, yellow tibiae, etc.; very strong setae throughout . . . . . 30. **FRONTINA.**

Small species, entirely dark coloured . . . . . 28. **PTYCHOMYIA.**

99. Abdomen without discal setae . . . . . (100)

Abdomen with discal setae . . . . . (105)

100. Arista with 2nd joint nearly or quite as long as the 3rd . 49. **GERMARIA.**

Arista with 2nd joint short and normal . . . . . (101)

101. Discal vein, *i.e.* 4th longitudinal, showing at the bending the rudiments of a vein running towards the hind margin, the so-called cubital appendage . . . . . (102)

Discal vein with no such cubital appendage . . . . . (103)

102. Three bristles in the dorso-central row behind the suture 42. **MICROTACHINA.**

Four bristles in the dorso-central row behind the suture . . 42. **TACHINA.**

103. Largish robust insects with wide abdomen, head somewhat swollen-looking; male with one fronto-orbital bristle on each side 22. **MASICERA.**

Somewhat smaller and less robust, head not swollen-looking; male with no fronto-orbital bristles . . . . . (104)

104. Discal vein (4th longitudinal) reaches margin distinctly before the tip of the wing; yellowish palpi and scutellum; medium-sized species 26. **ERYCIA.**

Discal vein reaches margin nearly at the wing-tip; black palpi and scutellum; small species . . . . . 27. **BACTROMYIA.**

105. Discal vein with a cubital appendage at the bending. 42. **CHAETOTACHINA.**
Discal vein with no cubital appendage at the bending . . . . (106)
106. Eyes small, lateralia therefore wide and equal to half the height of the eye. 91. **REDTENBACHERIA.**
Eyes larger, lateralia therefore narrower and at most barely one-third of the eye height . . . . . (107)
107. Apical portion of the discal (4th longitudinal) vein, from the position of the usual bending, usually more or less failing; legs chiefly yellow. 55. **RHACODINEURA.**
Apical portion of the discal vein always complete; legs mainly black (108)
108. Abdomen with discal macrochaetae not very distinct, not conspicuously differentiated from other long hairs, and even failing at times . . (108A)
Abdomen with the discal macrochaetae distinct . . . . . (109)
108A. Large species 9 mm. long or thereabouts; hind tibiae with a regular row of bristles on the outside, comb-like, with one strong central bristle. 12. **XYLOTACHINA.**
Small species only about 6 mm. long; hind tibiae with irregular bristles. 27. **BACTROMYIA.**
109. Arista thickened for the greater part of its length . 23. **PARAPHOROCERA.**
Arista thickened only at the base, at most for one-third of its length (110)
110. Males with short tarsal claws like the females . . . . . (110A)
Males with claws markedly lengthened, especially on the front pair of legs . . . . . (110B)
110A. Frons in male of similar width to that of female, and bearing fronto-orbital setae same; females have serrate underside to abdomen. 25. **MICROVIBRISSINA.**
Frons in male narrower than in female, and without fronto-orbital setae; females have normal undersides . . . . . 23. **CEROMASIA.**
110B. Hind tibiae with bristles in a regular even row, comb-like, with one large strong central bristle . . . . . 12. **XYLOTACHINA.**
Hind tibiae with an irregular series of bristles . . . . . 24. **LYDELLA.**
111. Facialia with the ciliation extending above the middle . . . . . (111A)
Facialia with the ciliation extending only a little way above the vibrissae (112)
111A. Face swollen-looking; genae wide, wider than the shorter diameter of the eye; antennae sunk into deep foveae . **BAUMHAUERIA** (non-British).
Face not swollen-looking; genae narrow and normal, narrower than shorter diameter of eye; antennae not sunk into the face 66. **ADMONTIA.**
112. Discal vein (4th longitudinal) with rudiments of a vein extending straight towards the hind margin (cubital appendage); postical cross-vein unusually obliquely slanted towards base of wing; head not swollen. 51. **VORIA.**
Discal vein with no cubital appendage; postical cross-vein normal; head rather conspicuously swollen . . . . . 50. **GONIA.**
113. Eyes clothed with hairs . . . . . (114)
Eyes bare . . . . . (124)
114. Edges of tergites widely separated beneath . . . . . (115)
Edges of tergites meet or nearly meet beneath . . . . . (116)
115. Large robust metallic-green species resembling *Lucilia*, etc. 5. **GYMNOCHAETA.**
Smaller slighter black species, not metallic coloured . 61. **DIGONOCHAETA.**
116. Abdomen with discal setae . . . . . (119)
Abdomen without discal setae . . . . . (117)
117. Antennae with 3rd joint fully three (♀) or four (♂) times as long as 2nd one; bending of discal (4th longitudinal) vein with no cubital appendage. 37. **Parasetigena silvestris** R.-D. (**media**, Rond).
Antennae with 3rd joint usually about double the length of the 2nd one; bending of discal vein with distinct cubital appendage . . . . (118)

118. Male with conspicuous red brush on genitalia; facial ciliation ascending less than half-way up the face and not quite reaching to the lowest of the descending frontal bristles; vibrissaria a little way above the epistoma.
43. **Tricholyga sorbillans,** Wiedm.

Males with genital hairs all black; facial ciliation ascending quite half-way up the face and passing the lowest of the frontal bristles; vibrissaria a little way above the epistoma.
43. **Tricholyga segregata,** Rond (non-British).

Males with genital hairs all black; facial ciliation ascending distinctly above the middle of the face, the bristles strong and widely separated; nevertheless, they do not reach the lowest of the frontal bristles, which do not descend far compared with the last two species; vibrissaria at the level of the epistoma and the underside of the head straight.
34. **Diplostichus janithrix,** Hartig.

119. Facialia with the ciliation extending upwards and reaching at least half-way up towards the antennal bases . . . . . (120)

Facialia with only a few bristles immediately above the vibrissaria . (122)

120. First posterior cell very narrow, its greatest width equal to little more than half the length of the subapical cross-vein; the bend of the discal (4th longitudinal) vein is thus flattened out forming a wide angle of about 140°. . . . . 33. **Campylochaeta obscura,** Fall.

First posterior wing-cell of normal width, its widest part equal to about two-thirds the length of the subapical cross-vein; the bend of the discal vein thus forms a sharper angle, often a right angle, and never much wider than that . . . . . (121)

121. Male with large and prominent genitalia projecting obviously beyond the last abdominal segment, and abdomen curved downwards somewhat; female has abdomen markedly curved downwards and the apical sternite projecting and strongly keeled and showing distinct striations.
38. **PHOROCERA.**

Male with smaller and less prominent genitalia which do not project beyond but beneath the last abdominal segment; abdomen not at all curved; female with abdomen not markedly curved and the apical sternite inconspicuous, not projecting, not at all keeled, and not striate.
9. **LYPHA.**

122. Eyes large, occupying most of head as seen in profile and leaving only very narrow lateralia . . . . . 14. **Carcelia comata,** Rdi.

Eyes medium or small with wide lateralia and genae . . . . . (122A)

122A. Genae with bristles . . . . . 59. **BLEPHAROMYIA.**

Genae bare . . . . . (123)

123. Shining black species. . . . . 10. **LYDINA.**

Dull species, dark, covered with greyish tomentum . 8. **EVERSMANNIA.**

124. Genae bare . . . . . (125)

Genae clothed with some hairs or bristles . . . . . (140)

125. Edges of tergites widely separated beneath . . . . . 65. **HELOCERA.**

Edges of tergites meet or nearly meet . . . . . (126)

126. Abdomen bearing discal as well as marginal macrochaetae . . . . (127)

Abdomen bearing marginal macrochaetae only . . . . . (137)

127. First posterior wing-cell closed and long stalked . . . . . (127A)

First posterior wing-cell open . . . . . (128)

127A. Males with no fronto-orbital setae; females with antennae short, 3rd joint not quite as much as three times as long as the 2nd; no marginal setae on the 1st visible abdominal segment . . . . 31. **ERYNNIA.**

Males with fronto-orbital setae; females with the 3rd antennal joint nearly four times as long as the 2nd; strong marginal setae on the 1st abdominal segment . . . . . 52. **ANACHAETOPSIS.**

128. First posterior wing-cell terminates on the margin before the wing-tip. (129)
First posterior wing-cell terminates on the margin at or nearly at the wing-tip . . . . . (130)
129. Discal or 4th longitudinal vein with a cubital appendage at the bend. 42. **CHAETOTACHINA.**
Discal or 4th longitudinal vein with no cubital appendage. 24. **Lydella albisquama,** Zett.
130. Abdomen long and compressed laterally . . . . . 88. **MINTHO.**
Abdomen normal, if long at least not compressed . . . . . (131)
131. Facialia with some ciliation at least on lower part . . . . . (132)
Facialia with a few bristles immediately by the vibrissaria only . . (133)
132. Legs unusually long and slender; frons in male narrow; vertical bristles appear as fine hairs only . . . . . 72. **DEGEERIA.**
Legs not unusually long or slender; frons in male wide, equal to at least half the width of an eye as seen from above; vertical bristles strong . (132A)
132A. Male possessing fronto-orbital setae like the female; female with serrate underside . . . . . 25. **MICROVIBRISSINA.**
Male with no fronto-orbital setae; female with normal underside. 23. **Ceromasia sordidisquama,** Zett.
133. Cubital vein (3rd longitudinal) bearing setae from the base to the discal cross-vein . . . . . 64. **THRYPTOCERA.**
Cubital vein with a few setae on the basal portion only . . . . (134)
134. Eyes small, lateralia as seen in profile equal to fully two-fifths of the eye height; 3rd joint of antennae but little larger than the 2nd. 73. **PELATACHINA.**
Eyes large, lateralia therefore only equal to about one-fifth of the eye height; 3rd joint of antennae twice as long as 2nd one or more . (135)
135. Apical scutellary bristles long and crossed, convergent 69. **ERYTHROCERA.**
Apical scutellary bristles divergent. . . . . (136)
136. Base of antennae inserted at a point at or below the level of the middle of the eye . . . . . 117. **MEDORIA.**
Base of antennae inserted at a point well above the level of the middle of the eye . . . . . 71. **APATELIA.**
137. Discal vein (4th longitudinal) bent angularly and possessing a cubital appendage . . . . . 42. **MICROTACHINA.**
Discal vein bent with a rounded curve with no cubital appendage . (138)
138. Subapical cross-vein, *i.e.* the apical portion of the discal vein, also the postical cross-vein, missing . . . . . 56. **PHYTOMYPTERA.**
Subapical and postical cross-veins present as usual . . . . . (139)
139. Cubital vein (3rd longitudinal) bearing fine setae from near base to discal cross-vein . . . . . 63. **ACTIA** (p.p.)
Cubital vein bearing a few setae only near its base . 68. **CRASPEDOTHRIX.**
140. Edges of tergites widely separated beneath . . . . . (141)
Edges of tergites meet or nearly meet beneath . . . . . (142)
141. Large species with shortly plumose arista . . . . 114. **HELICOBOSCA.**
Small species with bare arista (eyes sometimes rather hairy). 61. **DIGONOCHAETA.**
142. First posterior cell closed and stalked . . . . . 53. **WAGNERIA.**
First posterior cell open . . . . . (144)
144. Second joint of the arista lengthened, quite twice as long as wide; scutellum bearing apical setae . . . . . 66. **ADMONTIA.**
Second joint of the arista short; no apical setae on the scutellum. 67. **TRICHOPARIA.**
145. Vibrissaria on or close to edge of peristoma . . . . . (146)
Vibrissaria above the edge of peristoma . . . . . (150)
146. Epistoma slightly produced between the vibrissaria as seen in profile. 93. **ATROPIDOMYIA.**

Epistoma not produced between the vibrissaria as seen in profile . . (147)
147. Genae bearing bristles . . . . . 105. **Styloneuria.**
Genae bare . . . . . (148)
148. Abdomen with discal macrochaetae . . . . . (149)
Abdomen without discal macrochaetae . . . . . 93. **Atropidomyia.**
149. Antennae with plumose arista . . . . . 90. **Thelaira.**
Antennae with bare arista . . . . . 92. **Trixa.**
150. Epistoma more or less produced between the vibrissaria as seen in profile (151)
Epistoma not so produced (see No. 158, where this more properly belongs). 91. **Redtenbacheria.**
151. Genae bearing hairs or bristles . . . . . 99. **Dinera.**
Genae bare . . . . . (152)
152. Proboscis unusually long, projecting forwards and incapable of withdrawal. 98. **Prosena.**
Proboscis normal . . . . . (153)
153. First posterior wing-cell closed and stalked . . . . . 94. **Estheria.**
First posterior wing-cell open, or closed at the margin with at most only traces of a stalk . . . . . (154)
154. Abdomen with no discal macrochaetae . . . . . 100. **Myiocera.**
Abdomen with discal macrochaetae . . . . . 95. **Dexia.**
155. Head of the typical Tachinid type, underside short, facies long, vibrissaria near to the peristoma, profrons more or less produced, sometimes markedly so, epistoma not produced (Pl. IX, fig. 2) . . . . . (157)
Head squarish as seen in profile, underside being long, profrons produced, epistoma somewhat upcurved in front, facies thereby being usually shortened, vibrissaria usually at the level of peristoma, epistoma and vibrissaria being produced together (Pls IX and X, figs. 6 and 7) . (159)
Head seen in profile appears semicircular, the profrons not being produced much and the underside short and epistoma also not produced; facies short (Pls. IX and X, figs. 5 and 9) . . . . . (173)
Head viewed in profile with the facialia very much shortened owing to the vibrissaria being high above the peristoma; vibrissaria approximating, thus giving a constricted appearance to the lower part of the interfacialia (Pl. X, fig. 12) . . . . . (179)
Head with the greater part of the interfacialia domed and thus projecting between the vibrissaria; vibrissaria placed high above the peristoma (156)
156. First posterior wing-cell open, or closed at the wing-margin, with no stalk . . . . . 139. **Xysta.**
First posterior wing-cell closed and possessing a distinct stalk . . . (156A)
156A. Stalk of 1st posterior cell little more than one quarter the length of the 1st posterior cell itself; frons with bristly hairs covering a large part of the frontal orbits . . . . . 142. **Hyalomyia.**
Stalk of 1st posterior cell equal to fully half the length of the 1st posterior cell itself; frons with bristly hairs confined to the usual single row bordering the frontalia . . . . . 143. **Parallophora.**
157. Genae with a row of strong bristles parallel with the facialia and descending almost to the peristoma. They might easily be mistaken for facial bristles, but are not on the facialia . . . . . 122. **Metopia.**
Genae without any such bristles . . . . . (158)
158. Antennae thin short and porrected; arista not at all thickened; eyes nearly meeting on the frons in the male . . . 91. **Redtenbacheria.**
Antennae stout and closely adpressed, somewhat sunk into the facies between the facialia; arista thickened nearly to its end; frons wide in male and female alike . . . . . 54. **Ptychoneura.**
159. Genae bare . . . . . **Anthracomyia** (non-British).
Genae bearing hairs or bristles . . . . . (160)

160. Arista distinctly plumose, but on the basal half only . . . . . (161)
Arista bare, or with only very short ciliation, pubescent . . . . (166)
161. Abdomen covered with a shimmering tomentum which presents a tessellated appearance, the pattern changing with change of position . (162)
Abdomen either shining with little tomentum, or covered with nearly uninterrupted tomentum, or if there be a pattern of spots or lines these are more clearly defined and fixed and do not alter much according to point of view . . . . . (163)
162. Females with more or less projecting ovipositors, sometimes long and sickle-like; praesutural intra-alar bristle usually present; males with genital middle claspers cleft to base . . . **BLAESOXYPHA** (non-British).
Females with ovipositors withdrawn and inconspicuous; praesutural intra-alar bristle usually failing; middle claspers (mesolobe) of male genitalia only cleft part way . . . . . **SARCOPHAGA.**
163. Abdomen black and shining . . . . . 115. **NYCTIA.**
Abdomen covered with tomentum with or without dark spots . . (164)
164. Sixth abdominal segment (the 1st genital) in the male with conspicuous wart-like processes on each side; three sternopleurals in female.
112. **Agria mamillata,** Pand.
Sixth abdominal segments without such wart-like processes . . . (165)
165. Frons of male narrow, only about half eye width; female with 7th ventral segment enlarged, concave and shining . . . . 110. **TEPHROMYIA.**
Frons of male wide, fully of eye width; female with normal ventral segments; with four sternopleural bristles . . . 113. **SARCOPHILA.**
166. First posterior cell with a long stalk, more than half as long as the sub-apical vein (the portion of the 4th longitudinal beyond the bend) (167)
First posterior cell with only a short stalk, or with the cell closed at the margin itself, or open . . . . . (168)
167. Abdomen bearing discal macrochaetae . . . . 104. **PTILOCERINA,** ♂♂.
Abdomen without discal macrochaetae . . . . . 103. **STEVENIA.** ♂♂.
168. First posterior cell with a short stalk, which may almost disappear . (169)
First posterior cell open; sometimes nearly or actually closed at the margin . . . . . (171)
169. Abdomen with discal macrochaetae . . . . . 108. **PHYTO.**
Abdomen without discal macrochaetae . . . . . (170)
170. Antennae bases arising at a point above the level of the eye middle as seen in profile . . . . . 106. **FRAUENFELDIA.**
Antennae bases arising at a point below the level of the eye middle.
105. **STYLONEURIA.**
171. Eyes large, lateralia therefore reduced and narrow, equal to less than one-quarter of the eye height . . . . . 123. **SPHECAPATA.**
Eyes small, lateralia therefore wider, equal to about half the eye height (172)
172. Postical cross-vein reaches discal (or 4th longitudinal) vein midway between the discal cross-vein and the bending (legs partly yellowish; male with apical ventral plate deeply divided and produced conspicuously as a pair of lamellae, between which the genital segments lie).
106. **FRAUENFELDIA.**
Postical cross-vein reaches discal vein at a point nearer to the bending than to the discal cross-vein . . . . . (172A)
172A. Genal setae in a strong regular row diagonally across lower part of genae (robust species like a *Sarcophaga*; no discal setae) . . 119. **BRACHYCOMA.**
Genae with no really large strong setae, but with an unordered series of short setose hairs extending down the anterior portion of the genae, continuous with similar ones on the frontorbita (species with wide genae and lateralia; discal setae on 3rd and 4th visible segments).
101. **RHINOMORINIA.**

173. Genae bare (but see *Morinia*) . . . . . (174)
Genae bearing hairs or bristles . . . . . (176)
174. First posterior cell open (some individuals have a few hairs on the genae). 116. **Morinia.**
First posterior cell closed and long stalked . . . . . (175)
175. Arista with no distinct ciliation, scutellum with long apical macrochaetae. 102. **Plesina.**
Arista distinctly plumose (shortly), scutellum with very short apical macrochaetae . . . . . 107. **Melanophora.**
176. Discal vein (4th longitudinal) bent with a rounded curve and reaching wing-margin near the tip of the wing . . . . . (177)
Discal vein angulated at the bending . . . . . (178)
177. Small species, only about 4 mm. long, of slender build; genae almost and sometimes quite bare . . . . . 116. **Morinia.**
Larger species, of fully 6 mm. length, of robust build; genae with distinct row of strong bristles . . . . . 118. **Engyzops.**
178. Posterior cell closed and usually short-stalked; discal macrochaetae present . . . . . 108. **Phyto.**
Posterior cell open; cubital appendage at bending of discal vein; abdomen bearing no discal macrochaetae . . . . . 115. **Nyctia.**
179. Genae bare . . . . . (180)
Genae with hairs or bristles . . . . . (182)
180. Vibrissae undeveloped, if present very small and feeble 120. **Miltogramma.**
Vibrissae developed, large and crossing one another . . . . . (181)
181. Vibrissaria high above peristoma, markedly approached, so as to constrict the interfacialia; head rufous in colour, with yellow palpi; larger species . . . . . 121. **Setulia.**
Vibrissaria above peristoma, but not high and not markedly approached, so that interfacialia does not appear constricted; head not rufous at all; palpi black; smaller species . . . . . 123. **Sphecapata.**
182. Vibrissae not very far above the edge of the peristoma and not very strongly developed. . . . . 123. **Sphecapata.**
Vibrissae considerably above the edge of the peristoma and well developed (183)
183. Eyes large, lateralia therefore narrow, equal to about one quarter of the eye height; viewed in profile, head appears squarish . 121. **Setulia.**
Eyes small, lateralia wide, equal to about half the eye height; viewed in profile underside (succiput) slopes considerably to post-buccal angle. 125. **Macronychia.**
184. Second sternite exposed, but not free; its edges overlaid by the edges of the corresponding tergite; genae bearing strong bristles. 114. **Helicobosca.**
Second sternite quite free; its edges overlying the edges of the corresponding tergite; genae often bearing hairs, but never strong bristles . (185)
185. Vibrissaria high above peristoma and converging, so that interfacialia is markedly constricted . . . . . 126. **Pollenia.**
Vibrissaria often above the peristoma, but never high and never converging so as to suggest a constriction of the interfacialia . . . (186)
186. Epistoma produced more or less beak-like between the vibrissaria; vibrissaria above the peristomal edge . . . . . **Stomatorrhina.***
Epistoma may be slightly produced, but not much; vibrissaria not as a rule right on the peristoma, but epistoma and vibrissaria are somewhat upcurved together . . . . . (187)
187. Sternites exposed and very wide, equal to at least one-third of the width of the body in the male, and at least one-quarter of the same in the female; 5th sternite enlarged and conspicuously produced . . . (188)

* See Appendix (B).

Sternites narrower, never as much as one-quarter of the body width and usually one-fifth or less . . . . . (189)

188. Abdomen with marginal macrochaetae on the 2nd and 3rd segments; three pairs of acrostichals behind the suture . . . 133. **ACROPHAGA.**
Abdomen with no marginal macrochaetae on the 2nd segment, only on the 3rd, and only one pair of post-sutural acrostichals . . 132. **CYNOMYIA.**

189. Genae quite devoid of hairs even in the upper portion . . . . . (190)
Genae hairy . . . . . (191)

190. Face lengthened, distance from vibrissae to lunula about equal to distance from lunula to vertex . . . . . 128. **LUCILIA.**
Face shortened, distance from vibrissae to lunula much less than distance from lunula to vertex . . . . . 127. **PHORMIA** (p.p.)

191. Alulae with no conspicuous hairs on the disc . . . . . (192)
Alulae with distinct dark hairs on the disc . . . . . (193)

192. Abdomen with marginal macrochaetae on the 2nd visible segment; three post-sutural dorso-central setae . . . . . 131. **MELINDA.**
Abdomen with no marginal macrochaetae on the 2nd segment; face shortened . . . . . 127. **PHORMIA.**

193. Arista with long ciliations, feathered . . . . . 129. **CALLIPHORA.**
Arista bare on apical half, and only shortly plumose on basal half. 130. **ONESIA.**

194. Discal vein (4th longitudinal) with usual forward bend barely perceptible, vein continues almost in a straight line to the wing-margin. 137. **CINOCHIRA.**
Discal vein curved forwards as usual . . . . . (195)

195. Epistoma not produced, vibrissaria high above the peristoma; underside sloping considerably to post-buccal angle . . . . . (196)
Epistoma more or less produced; interfacialia usually distinctly convex on the lower portion . . . . . (197)

196. Lateralia very narrow; genae with numerous short bristles 135. **FRERAEA.**
Lateralia wide; genae quite bare . . . . . 136. **SYNTOMOGASTER.**

197. Vibrissaria at the level of peristoma and curved forwards together with the epistoma . . . . . 138. **WEBERIA.**
Vibrissaria above the peristoma; lower part of interfacialia (*i.e.*, epistoma), distinctly convex and produced between the vibrissaria . . . . (198)

198. Abdomen with distinct macrochaetae . . . . . (199)
Abdomen with no distinct macrochaetae . . . . . (200)

199. Legs black . . . . . 140. **CLYTIOMYIA.**
Legs yellow . . . . . **SUBCLYTIA** (non-British).

200. First posterior wing-cell open, or closed only on the wing-margin 139. **XYSTA.**
First posterior wing-cell closed, and with a stalk . . . . . (201)

201. Antennae long, both 2nd and 3rd joints lengthened and reaching practically to the bottom of the face; abdomen conspicuously convex on the upperside . . . . . 134. **GYMNOSOMA.**
Antennae short and reaching to about the middle of the face only; abdomen flat-looking on the upperside . . . . . (202)

202. Frons with the bristly hairs confined to the usual single row bordering the frontalia . . . . . 143. **PARALLOPHORA.**
Frons with the bristly hairs covering a large part of the frontal orbits . (203)

203. Stalk of posterior cell very short, only about one-quarter the length of the subapical cross-vein or upturned portion of the 4th longitudinal vein; face very wide as seen from in front; interfacialia distinctly narrower than a single gena . . . . . 141. **ALLOPHORA.**
Stalk of posterior cell about half the length of upturned portion of the discal vein; face narrower especially in the female; and even in the male the interfacialia is wider than a single gena . . . . 142. **HYALOMYIA.**

IV. The Genera and Species.

In the following list (as in the preceding), when describing a species as of a certain size, I have *Phryxe vulgaris*, Fall., in my mind as a typically medium-sized one; *Ernestia radicum*, F., as a typically large-sized one, and such as the common Actias as small-sized ones. Also *Phryxe vulgaris*, Fall., constitutes in my mind a typical-looking Tachinid in its shape, coloration, etc., and its general appearance is that of a very large number of the species in the Family.

When numbering the abdominal segments I count only the visible ones; morphologically the first visible one is commonly regarded as the true second, and Lundbeck so refers to it, but in the following pages it is called the first.

All measurements of the relative length of the antennal joints, also of the comparative sizes of eyes, lateralia and genae are reckoned as seen in strict profile. The second joint of the antennae frequently projects downwards in front, so that the relative sizes of the joints seen from in front would seem to be different, the second longer and the third shorter.

In estimating the relative width of frons and eyes, I have done it from directly above, from which point the line of the back of the head can be divided into three sections and compared. Mr. Collin is of opinion that I have tended to underestimate the width of the eyes, so that in cases of doubt this possibility may be remembered.

Further I must again warn students that important though the chaetal characters undoubtedly are, they are very liable to variation, the two sides of an insect even being often different, and setae normally present may fail or vice versa.

Subfamily TACHININAE.

1. Servillia, R.-D.

1. Smaller species, 11 mm. to 12 mm. long, usually with bright luteous side markings on the abdomen, though in some males these are almost wanting; legs with femora usually more or less yellow; pubescence comparatively short and nearly all yellowish; the whole insect shiny looking . . . . . **lurida,** F.
2. Larger species, but variable in size, sometimes no larger than *lurida*, other individuals may be as much as 16 mm. long, and stout in proportion; luteous side markings of abdomen usually failing, but when present not conspicuous or bright; femora dark throughout; pubescence long and dense, with many black hairs on the last two segments; not a shiny-looking insect . . . . . **ursina,** Mg.

Large stout flies, amongst our largest species of Diptera; readily distinguished apart from size by the characteristic antennae of this and the next two genera, with the 2nd joint longer than the 3rd, and by the dense downy pubescence which in *ursina* suggests some mimicry of the tawny-coloured Bombi. *Lurida* is a well-known New Forest insect, and I have also taken it in Herefordshire (West Hide); Col. Yerbury and others have taken it in various localities in Devonshire, and the Rev. E. N. Bloomfield at Guestling near Hastings. *Ursina* seems rather more widely distributed, but being a very early spring species, occurring in March and April, it is probably often missed through inclement weather and the absence of collectors so early in the season. Mr. R. C. Bradley and I once in 1894 met with it in great abundance in Wyre Forest

between March 24 and 27, when weather conditions happened to be very favourable. I have notes of its occurrence in the New Forest, at Maidstone, Chingford, Walton-on-Thames, Oxshott, Crowborough, in Devonshire, etc. Usually the two species can be separated at a glance, but occasionally specimens occur which are sufficiently alike to lead to confusion, and close attention to the characters is required.

2. ECHINOMYIA, Dumèr.

1. Abdomen all black, our largest Tachinid . . . . . **grossa,** L.
   Abdomen partly reddish . . . . . 2.
2. Legs almost entirely reddish . . . . . **fera,** L.
   Legs nearly all black; palpi clubbed. (Subgen. *Fabriciella*) . . **ferox,** Panz.

Again large stout species, readily identified apart from their size by the characteristic antennae as in the last genus.

Magnicornis, Zett. (subgen. *Eudoromyia*), was recorded as British in error by Mr. G. H. Verrall (*E.M.M.*, 1911, p. 79). It may occur here and would be easily confused with *fera*, which it closely resembles. In the male sex it could be recognised by the possession of a much wider frons, and fronto-orbital bristles, such as usually occur only in the females of the genus; also it has a large square 3rd antennal joint. In the female it is not so readily distinguished from *fera*, but usually has darker legs and especially blacker tarsi, and a rather wider frons.

Fera is a common and widely distributed species, at least in the southern half of England, and has been recorded from Ireland. It is very abundant in the autumn in Wyre Forest, and I have it from Sherwood Forest, which happens to be my most northern record. It is a conspicuous, brightly rufous insect. *Grossa* is again a well-known New Forest fly, and appears to be frequent in Cornwall and Devon, and has been recorded from a number of scattered localities including Scotland (S. Sutor, Cromarty, W. R. O. Grant; Kirkcudbright, T. G. G. Strickland, etc.), and Ireland (Stradbally, H. W. Andrews, etc.). The great size and all-black colour (excepting for some pubescence on the head) render this an unmistakable species.

Ferox, a very handsome red and black fly, seems to occur chiefly in Cornwall and Devon, but I have a number of records from scattered localities in the southern half of England.

3. PELETERIA, R.-D.

Nigricornis, Mg. (= **tessellata,** Zett.), the only species. Large flies, nearly as large as *Echinomyia fera*, and similar in appearance. Readily distinguished by the strong genal bristles. There are two males in the Cambridge University Museum, unfortunately without data, but supposed to be British. They seem to be rather dark specimens of this species, and are dark enough to lead one to believe that they might belong to a northern form and so not improbably be truly British; nevertheless further captures are desirable for confirmation.

Dr. Villeneuve tells me that *prompta*, Mg., usually regarded as this species, is really *jugorum*, Strobl.

4. MICROPALPUS, Macq.

1. Legs with femora and tibiae almost entirely yellow. . . . **vulpinus,** Fall.
   Legs with femora and tibiae almost entirely dark . . . . . 2.

2. With fronto-orbital setae in the male, and hinder cross-veins so placed that the bending of the 4th longitudinal vein is four or more times as far from the hind margin of the wing as from the postical cross-vein (*Linnaemyia*) . . . . . **comtus,** Fall.
No orbital setae in the male, and bending of the 4th longitudinal only twice as far from the hind margin as from the postical cross-vein . . 3.
3. Buccae clothed with long but fine hairy down; genitalia in male always dark, setae on 3rd longitudinal vein extend nearly to cross-vein and are normally as many as thirteen in number . . . . . **pudicus,** Rdi.
Buccae clothed with distinct bristle-like hairs; genitalia in male yellow; setae on 3rd longitudinal vein restricted to a short length near the base, and normally about seven in number . . . . **haemorrhoidalis,** Fall.

Large plump species, smaller than those of the preceding genera, and about the size of the Ernestias, which they resemble; they are, however, readily distinguished by well-developed cubital appendages to the bending of the 4th longitudinal vein and by the small size of the palpi, small in all species but almost wanting in *vulpinus*, Fall., and *comtus*, Fall.

Vulpinus is the common species; it is widely distributed, and I have seen it in Wyre Forest in great abundance. It is brightly yellowish or reddish in colour and readily distinguished at a glance from the other species, all of which are dark coloured. *Comtus*, Fall., seems to be very rare; I only know of one male from Bisley Common, a female in the British Museum from North Sutor, Cromarty, and one in the Verrall collection from Lewes. *Pudicus* seems to be not uncommon in some localities in the south of England, and *haemorrhoidalis* the same in the north of Scotland. Col. Yerbury took long series of the latter at Aviemore, Nethy Bridge, Brodie, etc., and I found it at Rannoch; and the former has been taken at Bexley (H. W. Andrews), Lamorbey (Andrews), Colchester (W. H. Harwood), Farningham (Andrews), etc., Wingate (27) records *haemorrhoidalis* from Shull.

5. Gymnochaeta, R.-D.

Viridis, Fall., the only species of the genus is not uncommon. It is a shining green fly like the Lucilias and Pyrellias (greenbottle flies), with which it seems to be bound in some mimetic association; it is, however, readily distinguished from them by the strongly developed macrochaetae with which it is armed. I have records from the north of Scotland to Devonshire, and also from Ireland (Glengariff, H. W. Andrews).

6. Ernestia, R.-D. (See Pl. IX, fig. 1.)

Males.

1. Species with the frons very narrow, being one-quarter or less than one-quarter of the width of one eye at the vertex; ocellary and vertical setae thin and hair-like. . . . . Subgen. **Panzeria,** R.-D. 2.
Species with frons varying in width but never quite so narrow as in *Panzeria*, at least one-third of eye width at vertex; ocellary and vertical setae always strong and well developed . . . . . 3.
2. Larger species; frons only about one-fifth of eye width, or at most barely one-quarter; apical scutellary setae present, making five pairs of marginal setae; antennae usually more or less rufous . . . . . **rudis,** Fall.
Smaller species; frons fully one-quarter eye width, perhaps even nearly one-third; no apical scutellary setae, making only four pairs of marginals; antennae usually all dark . **nielseni,** Villen. (= **minor,** Villen. & Nielsen).

3. The usual crossed apical scutellary bristles failing; hindermost pair always parallel.
Subgen. **Fausta,** R.-D. (= **Echinosoma,** Girsch.) **nemorum,** Mg. (= **pectinata,** Girsch.).
A pair of crossed apical scutellary bristles always present . . . . . 4.
4. Species with the 2nd antennal joint a trifle longer than the 3rd (a hair-splitting character requiring close observation); four D.C.; abdomen covered with a tessellated tomentum; strong discals on 1st abdominal segment . . . . . Subgen. **Eurythia,** R.-D., **caesia,** Fall.
Species with 3rd antennal joint longer than 2nd one . Subgen. **Ernestia,** R.-D. 5.
5. Second joint of arista lengthened, three or four times longer than wide. Subgen. **Appendicia,** Stein, **truncata,** Zett.
Second joint of arista short and inconspicuous . . . . . 6.
6. White tomentum of abdomen clearly confined to 2nd and 3rd segments only (sometimes there is a little at the sides only of the 4th) . **radicum,** F.
White tomentum extends to 4th segments also . . . . . 7.
7. Palpi yellow . . . . . 8.
Palpi black . . . . . 9.
8. Frons narrow, barely one-third of eye width . . . . . **consobrina,** Mg.
Frons wider, about half of eye width . . . . . **vivida,** Zett.
9. Frons narrow as in *consobrina*, of which it may be a variety . **connivens,** Zett.
Frons wide, half eye width or even wider. **conjugata,** Zett. (= **latifrons,** Br., and **intermedia,** Zett.).

Females.

1. Fore tarsi considerably widened, even the 1st or metatarsal joint usually somewhat widened towards the tip, and the next joint at least as wide as long . . . . . **rudis,** Fall.
Fore tarsi much slenderer and not markedly widened, but generally a little spread, and the 3rd and 4th joints generally as wide as long, the 2nd, however, always longer than wide . . . . . 2.
2. No crossed apical scutellary setae . . . . . 3.
With crossed apical scutellary setae always present . . . . . 4.
3. Strong discal and marginal setae on the 1st abdominal segment; three D.C.; three pairs marginal scutellary setae as a rule; all joints of tarsi longer than wide . . . **Fausta,** R.-D., **nemorum,** Mg. (= **pectinata,** Girsch.).
No discal and not very strong marginal setae on the 1st abdominal segment; four D.C.; four pairs marginal scutellary setae as a rule; tarsi widened a little as in other species . . **nielseni,** Villen. (= **minor,** Villen. & Nielsen).
4. Arista with 2nd joint conspicuously lengthened, three or four times as long as wide; usually with a cubital appendage at bending of 4th longitudinal vein . . . . . **truncata,** Zett.
Arista with short and inconspicuous 2nd joint . . . . . 5.
5. Frons at vertex wide, quite one and a half times a single eye width. **conjugata,** Zett.
Frons at vertex narrow, distinctly less than a single eye width. **connivens,** Zett.
Frons at vertex about the width of a single eye . . . . . 6.
6. Last segment shining, with only a little tomentum at sides of fore margin; tomentum chiefly confined to 2nd and 3rd segments as in the male sex, but not quite so sharply defined . . . . . **radicum,** F.
Last segment with tomentum as on the 2nd and 3rd . . . . . 7.
7. Second antennal joint longer than 3rd (a very fine character and requiring careful observation); palpi quite black . . . . . **caesia,** Fall.
Second joint of antennae shorter than the 3rd; palpi yellow . . . . 8.
8. Four D.C. . . . . **consobrina,** Mg.
Three D.C. (a doubtful species of which I know little) . . . **vivida,** Zett.

Large plump dark-coloured flies, fairly easily recognised by the lengthened 2nd antennal joint, which approaches the length of the 3rd, and the prominent epistoma and profrons and generally square-looking face; lateralia wide, about equal to half eye height; genae bare, eyes hairy; and abdomen with discal macrochaetae. It is a difficult genus, the species are very like one another, and great care is required for successful differentiation; it is probably one of the genera that would be helped by an intensive study of the genitalia, etc. The females are even more difficult than the males, but it is hoped that the tables will help.

Rudis, Fall., is the commonest of the species, and is frequently to be met with in woods in early June or even in May, sometimes in considerable numbers; it seems to be particularly fond of the flowers of *Euphorbia*. It can be recognised by the very narrow frons of the male and very wide tarsi of the female, and is also the largest species in the genus. *Nielseni*, Villen., is also, I believe, a fairly common species which, however, has hitherto been much confused with *rudis*. I have had it in my collection for years separated from *rudis*, Fall., under the name *nemorum* (Mg.) B. & B., with a query as to the name, and as far back as 1910 sent specimens to Dr. Villeneuve calling attention to some of the differences between the two species, but could not at that time convince him that it was anything but a small form of *rudis*; then in 1916 Nielsen sent him specimens from Denmark, and they were described as a new species under the name *minor*, Vill. & Niels. Since then Villeneuve has renamed the species, as *minor* proved preoccupied, and he appropriately called it *nielseni*. Stein (24) described it afresh as a new species, again under the name *minor*, Villeneuve's earlier description being apparently overlooked. I still think that it was this species that Brauer referred to in *Sitz. K. Akad. Wissen. Wien*, Bd. cvii, Abth. I, 1898, p. 532, as *nemorum*, Mg., but Dr. Villeneuve tells me that Meigen's type of that species belongs to the species afterwards described as *Echinosoma pectinata* by Girschner and introduced to the British list under that name by Major Austen (*E.M.M.*, 1905, p. 57). I suspect that some of the earlier descriptions of species in this genus really applied to *nielseni*, but it has not been well characterised until now, and for the time being Villeneuve's name holds the field. It is smaller than *rudis*, Fall., as a rule, although equally small *rudis* do occur, and all its macrochaetae are thinner and more hair-like than in any other species of *Ernestia*, and are also rather more numerous, so that we find four D.C., four pairs of marginals on the scutellum, and sometimes even a fifth pair which is apical, but always small and never crossed; on the other hand, the discals of the 2nd abdominal segment are so reduced as to be practically missing, and this affords a useful character even in the female, separating it from *nemorum*, Mg. (= *pectinata*, Girsch.), the only other species which has no crossed scutellary apicals. *Nemorum* is also distinguished from *nielseni* by shorter 2nd aristal joint, less tomentum, black scutellum and little if any rufous on the abdomen.

Radicum, F., is another very common species, more especially occurring in July and August, but I have never found it in any numbers in any one locality. It also is a fairly easy species to identify owing to the silvery tomentum failing on the 4th abdominal segment, which is thus shining black and contrasts with the 2nd and 3rd segments.

Consobrina, Mg., may prove to be fairly common, but I know of only a few specimens at present, several of which are from Ireland. *Truncata*, Zett., is not rare and is easily recognised by the very elongated 2nd aristal joint, and it usually shows a well-marked cubital appendage at the bending of the 4th

longitudinal wing-vein; Col. Yerbury found it commonly in Scotland. *Caesia*, Fall., seems rare, and I only know of it from Folkestone (L. A. Spencer) and Culford, Suffolk (Col. C. G. Nurse). Austen introduced *nemorum*, Mg. (*Echinosoma pectinata*, Girsch.), to our list (*E.M.M.*, 1905, p. 57) on a single female taken by Col. Yerbury in Herefordshire, and there is another in the Brit. Mus. Coll. from Herts (A. Piffard) and an old specimen in the Hope Museum. Austen also recorded (*loc. cit.*) *conjugata*, Zett. (as *intermedia*, Zett.), from specimens taken at Porthcawl by Col. Yerbury, but I know of no other British captures of either of the two above species. Villeneuve is my authority for the name *conjugata*, Zett.; he tells me that it is identical with *intermedia* of Stein and B. & B., and also with *latifrons*, B. &. B. (*sec. typ.*).

Connivens, Zett., is a species about which I feel doubt. I have what I believe to be a male of this species from Stradbally, Ireland (H. W. Andrews); and *vivida*, Zett., is even more doubtful, although there is what I believe to be a male of this species in the Brit. Mus. Coll. (Felden, Herts, A. Piffard). In his recently published posthumous work Stein (24) erects the genus *Appendicia* for *truncata*, Zett.; in my view we have far too many genera already, and at most I should treat this as another subgenus of *Ernestia*, R.-D.

Stein considers that *vagans*, Mg., is distinct from *rudis*, Fall., and Mr. J. E. Collin has specimens so named in his collection. *Rudis*, however, is a very variable species, and I do not at present regard *vagans* as representing anything other than a form or forms of that species. Stein's characters are (*a*) in *vagans*, three praesutural acrostichals, three dark lines on the thorax, slight development of the red colour on abdomen, and sharply defined abdominal bands; and (*b*) in *rudis*, two praesutural acrostichals, four lines on the thorax, increased development of the red colour on the abdomen, and less distinctly defined abdominal bands. If *vagans* should prove to be a good species, it will doubtless be found to be common.

7. Meriania, R.-D.

One species only, **puparum,** F., a large easily recognised fly of which I possess one male only from Holmbury (Dr. T. A. Chapman), and Mr. Collin has two others from the same place; I have also seen one in the British Museum from Wisley (G. Fox Wilson), and another from Berks (A. H. Hamm). Its very hairy genae separate it at once from the Ernestias, which it resembles in size and general appearance; and the shortened face, due to the vibrissaria being above the peristomal edge, is very characteristic. In 1902 (*Entomologist*, xxxv, pp. 249–52) *argentifera*, Mg., was recorded by me as a second British species of this genus. The specimen upon which the record was based, however, proved on further examination to be a slightly aberrant form of the common species since described as *Panzeria nielseni*, Villen. (= *minor*, Villen. & Niels.). *Minor* occasionally possesses a few scattered hairs on the upper part of the genae and in this specimen they were a little more numerous than usual, and, owing to some shrinkage of the cranium, they had the appearance of coming further down the genae than is the actual fact. *Argentifera* is a very similar species and might easily get mixed up with *nielseni*, but so far as I know it is not British.

8. Eversmannia, R.-D.

One species only, **ruficauda,** Zett., a smallish narrow species similar in general size and shape to the common *Phryxe vulgaris*, Fall. Possessing distinctly rufous genital segments, an uncommon character, it is easily recog-

nised. The male has peculiar fans of black hairs on the hind margin of sternites; frontal setae descend well below aristal bases. I possess two specimens, a male from Rannoch and a female taken by Mr. H. W. Andrews at Hickling. Mr. J. E. Collin has one from Dornoch, there is one at Cambridge taken by Dr. Sharp at Nethy Bridge, and Dr. W. J. Fordham has one taken presumably in the neighbourhood of Gateshead, but I know of no other British specimens. It seems to be a northern insect.

9. Lypha, R.-D.

Again one species only, **dubia,** Fall., a small, somewhat yellowish-brown plump species which should be recognised from the tables, but belongs to a large group of hairy-eyed characterless species. One of our commonest Tachinids, sometimes occurring in great numbers in woods in spring. It has rather prominent male genitalia; frons = half eye width; 3rd antennal joint about twice the length of 2nd one; frontal setae descending genae to below aristal bases and reaching to the fine ascending facial setae; hind-marginal wing-vein strongly incurved.

10. Lydina, R.-D.

Another genus with but a single species, **aenea,** Mg., a distinctive insect, very shiny black, with bright yellow bases to the wings. It has a wide frons, even in the male exceeding eye width, with shining frontorbita, and supplementary frontals. The arista has the 2nd joint distinctly elongated and the 3rd thickened nearly to the tip. Not uncommon and widely distributed.

11. Nemoraea, R.-D.

Pellucida, Mg., is a very rare species, a large one, as large as *Echinomyia fera,* L., and in the male sex not unlike it in coloration, though the female has no rufous colour on the abdomen. It has a wide abdomen without discal setae; small eyes, the lateralia thus wide and over half eye height; slight antennae, the 3rd joint half as long again as the 2nd and yellowish; the face rather short; the alulae with a conspicuous covering of mixed dark and light hairs. I have one New Forest specimen only, and have seen a pair from the same locality bred from pupae of *Taeniocampa stabilis,* View, by Mr. G. T. Lyle, and another taken by Dr. Sharp. Mr. Verrall has a pair from Guestling, Hastings, taken by the Rev. E. N. Bloomfield in 1886, and also an old one without data, and those are all the British specimens of which I have knowledge. In the Verrall List the name *nupta,* Rond., occurs, but I suspect that the record was based upon the specimens which I identify as *pellucida,* Mg. *Nupta* is supposed to be smaller, with darker antennae, and the last abdominal segment in the male also darker, practically all black; it is a species, however, which I do not know and have failed to distinguish hitherto, and which may prove to be only a small form of *pellucida,* Mg.

12. Xylotachina, B. & B.

A monotypic genus, erected by B. & B. for their species **ligniperdae,** B. & B. (= **diluta,** Mg.), the chief generic distinction from *Sturmia,* R.-D., and its allies being the possession of discal macrochaetae. Col. Yerbury took a pair on a *Cossus*-infected tree at Lyndhurst Road on July 1, 1897, which are now in Mr. Collin's collection, and I think they must belong to this species, although not wholly agreeing with Brauer and von Bergenstamm's description. The discal setae are irregular and not very long and strong; the lateralia are

not narrow, but nearly two-fifths of eye height, and the arista is thickened only at the base. They may, of course, belong to a closely allied species, but it seems likely from the association with *Cossus* that our specimens belong to B. & B.'s species. It is at present the only British representative of a group consisting of robust flies with *bare* eyes, normal Tachinid head, and regularly ciliated hind tibiae, the latter being the chief distinguishing character of the group, other species of which may yet be found here.

13. Winthemia, R.-D.

1. Anal segments entirely dark, no rufous coloration; large dark species; with three sternopleural setae; no macrochaetae on the 3rd abdominal segment (*Chaetolyga*) . . . . . **amoena,** Mg.
   Anal segments more or less rufous; smaller species with more or less fulvous coloration . . . . . 2.
2. Species with macrochaetae on 3rd abdominal segment . . . **variegata,** Mg.
   Species with no macrochaetae on 3rd abdominal segment; two sternopleural setae only . . . . . **quadripustulata,** F.

Species easily recognised by the large hairy eyes, hairy genae, and narrow lateralia, and the even ciliation of the hind tibiae.

Quadripustulata, F., is a common, well-known, medium-sized species, possessing conspicuously rufous anal segments and rather a wide flattened abdomen. The other two species are rare, and I am by no means certain yet about *variegata*, Mg. Dr. Villeneuve informed me that there is only one species with discals on the 3rd abdominal segment, and he identified a Swiss specimen of mine as being *variegata* and in accordance with Meigen's type. Comparison of this with two male specimens from the Cambridge Museum taken by T. W. Kirkpatrick revealed some lack of agreement, the Cambridge ones being clothed with longer, stronger and almost bristle-like pubescence giving them an altogether more setigerous appearance, and there seemed also other minor differences.* Villeneuve considers *variegata*, Mg., to be identical with *nigrithorax*, Egger, which name would disappear excepting as a synonym, if this proves to be the case. *Amoena*, Mg., should be easily recognised; I have seen about a dozen, of which the majority were old specimens from Darenth and Denmark Hill in Mr. Verrall's collection, and the others were from Hogley Bog, Oxford (A. H. Hamm), Cambridge, and Devonshire. Mr. Collin also has it from Kirtling, Cambridgeshire, and from Bury St. Edmunds.

14. Carcelia, R.-D.

1. Abdominal segments with marginal macrochaetae only . . . . . 2.
   Abdominal segments with discal as well as marginal macrochaetae . . 4.
2. Anterior tibiae with only one strong central bristle on the outside; species covered with yellowish tomentum and so appearing yellow (*gnava* occasionally has only one tibial bristle, but it is a greyish not yellowish insect) . . . . . **excisa,** Fall.
   Anterior tibiae with two central bristles on the outside; species covered with greyish-white tomentum through which the dark ground-colour shows, so that insects are distinctly greyish in appearance . . . . 3.
3. Frons narrow; in the male it is a trifle more than half the width of one eye; in the female fully two-thirds the same . . . . **bombylans,** R.-D.

* I have since seen a pair from Woodperry Wood, Stanton St. John, near Oxford, taken by Mr. J. Collins, like the Cambridge ones and equally unlike my Swiss ones.

Frons wider; in the male it is just about the same width as in the female of the preceding species; in the female it is over three-quarters of the eye width (this species occasionally has only one seta on the outside of each front tibia) . . . . . **gnava,** Mg.

4. Abdomen comparatively narrow; covered like *excisa* with yellowish tomentum, making it a yellow insect . . . . **rutilla,** B. & B. (*nec* Rond.).

Larger species with widened abdomen, covered with greyish-white tomentum with the dark background showing through and thus a typically grey Tachinid . . . . . **comata,** Rond.

Typical Tachinids with hairy eyes very much like *Exorista* and other common genera, but can be recognised by very narrow lateralia, regularly ciliated hind tibiae and yellow tibiae and scutellum.

An extremely difficult genus; somewhat variable insects, with a multitude of names representing probably very few distinct and reliable species; and it is almost impossible without a thorough study of all the types to decide what names to use for such species as one may fancy one can recognise. It is desirable for the species to be taken in long series for close examination, long series if possible from a single place at one time, and then one might arrive at something resembling certainty, and I think the result would be that most of the supposed species would disappear as inconstant varieties of others. Perhaps I have cut my list too short, but of the five species with which I deal only two are clearly defined, *excisa*, Fall., and *rutilla*, B. & B., the other three all belonging to the group of uncertainties, and although perhaps it may be extreme to suggest that they all represent but one real species, yet I certainly feel that they are not species of full value. I am doubtful about my own specimens and still more so about any I may have seen and ventured to name for others, so that I can say little of use about their distribution. All seem rare; of *excisa*, Fall., I am certain of one female only from Lynton; of *rutilla*, B. & B., I took one female in Hay Wood, Warwickshire, and have seen one taken by Dr. J. H. Wood in Herefordshire and another taken by Mr. H. Britten in Delamere Forest. *Gnava*, Mg., is, I think, the commonest, and I have it from the New Forest, Torquay, Warwickshire, etc., and have seen others; *comata*, Rond., I have from Lynton, Studland (Dorsetshire), Wyre Forest and have seen others; *bombylans*, R.-D., I have from the New Forest and Tenby. Villeneuve considered that he could separate a species *susurrans*, Rond., from *excisa*, Fall., the former having a comparatively narrow abdomen, the latter a wide, fat-looking one; again, he separated *lucorum*, B. & B., from *bombylans*, R.-D., on the same grounds, *lucorum* being the narrower species: in this case he says that the pilosity is more upright in *lucorum* and flat in *bombylans*; again, he separated *comata*, Rond., and *cheloniae*, Rond., in the same way, *comata* being the narrower species; and he recognised still another species *biserialis*, S. (= *comata*, Mik & Wachtl.), which he says has a very wide frons and has the facial setae ascending high. All these species or forms are quite likely to occur in this country and might prove to be quite sound species on further investigation, but Dr. Villeneuve himself is doubtful.

15. 16. 17. EXORISTA, Mg., etc. (See Pl. IX, fig. 2.)

I have brought together here species belonging to three so-called genera of the hairy-eyed group of the typical looking TACHINIDAE, because they are so much alike that it is only by a tabular comparison of them all in this manner that it seems possible to assist identification. The species included in this table

belong not only to the genus *Exorista*, but also to *Zenillia*, R.-D., and *Phryxe*, R.-D. (*sens. lat.*).

1. Frons at vertex as seen from above distinctly narrower than the width of a single eye as seen from the same point of view . . . . . 2.
   Frons at vertex as wide or wider than a single eye, or at least not so much narrower as to be obviously so (see *tritaeniata*, Rond., in which it may be slightly narrower) . . . . . 7.
2. Third joint of antennae not more than three times as long as the 2nd one, and often decidedly less . . . . . 3.
   Third joint of antennae as much as four times as long as the 2nd and often more . . . . . 6.
3. Ocellary bristles failing; four sternopleural setae; no discal macrochaetae (palpi and scutellum yellow; 3rd antennal joint about twice the length of the 2nd one) . . . . . **lota,** Mg. (**immunita,** Pand.) ♂.
   Ocellary bristles present; usually only three sternopleurals; abdominal discal macrochaetae present (short and sometimes not very obvious in *glauca*, Mg.) . . . . . 4.
4. Vibrissaria on a level with the lower edges of the eyes, and thus well above the level of the lower edges of the buccae; the buccal edges slope away from the vibrissaria so as to make it seem as if the face were actually continued below the vibrissaria, which however is not the case; palpi black; scutellum slightly rufous tipped; 3rd antennal joint about three times as long as the 2nd; frons four-fifths of eye width. **pexops,** B. & B. ♂.
   Vibrissaria normally placed and appearing therefore to be at the bottom of the face and on a level with the lower buccal edge . . . . . 5.
5. Third antennal joint about three times the length of the 2nd; palpi black; frons narrower than in *pexops*, B. & B., in ♂ equal to three-fifths eye width. Scutellum yellow, and apical setae curved upwards and forwards . . . . . **agnata,** Rond. ♂.
   Third joint of antenna fully three times the length of the 2nd; frons at vertex two-thirds as wide as one eye; one pair only of recurved praevertical setae; palpi black; scutellum black with apical pair of setae curved backwards and downwards . . . . . **mitis,** Mg. ♂.
   Third antennal joint only about twice the length of the 2nd or two and a half times at most; discal macrochaetae often indistinct; palpi yellow; frontal setae running down on to the genae in a single ordered row, and not very numerous; apical scutellary bristles curved backwards and downwards; two pairs of recurved praevertical bristles; irregularly ciliated tibiae . . . . . **glauca,** Mg. ♂.
   Third antennal joint fully three times the length of 2nd; only one strong pair of recurved praevertical bristles; tibiae regularly ciliated and comb-like; a rather larger and more bluish-coloured species; palpi yellow. **hortulana,** Mg. (**blepharipoda,** B. & B.) ♂.
   Third antennal joint about twice as long as the 2nd; discal macrochaetae numerous and distinct; palpi yellow; frontal setae on upper part of genae numerous and irregularly placed, not in a row; apical scutellary bristles recurved and bent upwards and forwards . . **affinis,** Fall., ♂.
6. Small blackish species, 7 to 8 mm. in length; apical scutellary bristles curved upwards and forwards . . . . . **roseanae,** B. & B. ♂.
   Larger species about 9 mm. in length, covered with yellowish tomentum so as to have a generally yellowish appearance; palpi and scutellum yellow; frons very narrow, not more than two-fifths of the width of one eye as seen from above . . . . . **libatrix,** Panz. ♂.

7. Third antennal joint not more than three times the length of the 2nd, often still shorter in proportion . . . . . 8.
Third antennal joint four times the length of the 2nd or even more . . . 18.
8. Ocellary bristles failing; four sternopleurals present; no discal macrochaetae; palpi and scutellum yellow; 3rd antennal joint less than twice the length of the 2nd . . . . . **lota,** Mg. (**immunita,** Pand.) ♀.
Ocellary bristles present: usually three sternopleurals only . . . . . 9.
9. Palpi yellow, at least widely so at the tip . . . . . 10.
Palpi dark . . . . . 13.
10. Species yellowish in appearance through being covered with yellowish tomentum; palpi and scutellum yellow . . . . **libatrix,** Panz. ♀.
Species of dark or greyish appearance, the white or grey tomentum leaving the dark surface beneath showing through . . . . . 11.
11. Numerous frontal setae descending on to the upper part of the genae in an irregular double row; abdominal discal macrochaetae distinct; abdomen very setose . . . . . **affinis,** Mg. ♀.
Frontal setae descending on to the genae in a single regular row and not very numerous, about five or six in number . . . . . 12.
12. Only one strong pair of recurved praevertical bristles; hind tibiae with regular comb-like ciliation; large species (about 10 mm. long), somewhat bluish-grey in colour . . . **hortulana,** Mg. (**blepharipoda,** B. & B.) ♀.
Two strong pairs of recurved praevertical bristles; no definite comb-like ciliation on hind tibiae; no blue tone in the grey colour . . **glauca,** Mg. ♀.
13. Second and 3rd segments of the abdomen with no discal macrochaetae, or at most with short and irregular ones . . . . . 14.
Second and 3rd segments with distinct discals which are as long and regular as the hind-marginal ones . . . . . 15.
14. Scutellum yellowish . . . . . **cincinna,** Rond. ♂ (♀?).
Scutellum black . . . . . **tritaeniata,** Rond. ♀.
15. Scutellum black; apical scutellary bristles backwards and downwards curved . . . . . 16.
Scutellum yellowish; apical scutellary bristles upwards and forwards curved . . . . . 17.
16. Facialia with ciliation ascending nearly or quite to the middle; larger species (9 mm.); succiput as seen in profile sloping distinctly from the epistoma downwards to the post buccae; or epistoma may be described as standing at a level distinctly higher than the lower edge of the head; two backward curving praeverticals on each side; abdomen with tomentum almost covering the segments . . . **pexops,** B. & B.* ♀.
Facialia with bristles near to vibrissaria only; succiput normal; one pair recurved praevertical setae; 3rd antennal joint about two and a half times the length of the 2nd; 1st posterior wing-cell ending near tip of wing . . . . . **mitis,** Mg. ♀.
Facialia with a few bristles near to the vibrissaria only; size as in *pexops*; succiput straight, not notably sloped; epistoma at a level but little above the lower edge of the head as seen in profile; usually only one backward-curving praevertical on each side; abdomen with tomentum widely spread; 3rd antennal joint three times the length of 2nd; 1st posterior wing-cell ending near wing-tip . . . **westermanni,** Zett. ♀.
Facialia with a few bristles only, near to the vibrissaria; smaller species (7 mm.); succiput straight; epistoma practically on a level with the lower edge of the head; two recurving praeverticals; abdomen with tomentum restricted to a narrow clearly defined line on fore margins of

* The name of this species is in much doubt; if, however, the synonymy quoted by Lundbeck is all correct, *brachystoma*, B. & B., seems to have the best claim.

each segment. 3rd antennal joint less than twice as long as lengthened 2nd; 1st posterior wing-cell ending abruptly considerably before wing-tip . . . . . **fimbriata,** Mg. ♂♀.

17. Frons at vertex just about equal in width to one eye, as seen from above; facialia with ciliation not ascending, only just a few bristles close to the vibrissaria; frontal setae on upper part of genae only three or four in number and not descending below level of arista; frontalia dark, and the whole head showing blackish reflections; three strong praeverticals or upper outward and backward curving frontal bristles . **agnata,** Rond. ♀.

Frons at vertex about one and a quarter times the width of a single eye as seen from above; facialia with ciliation not ascending; only three frontal setae descending on to upper part of genae and barely reaching the level of the arista; head yellowish-looking through yellowish tomentum, with little tendency to show blackish reflections; two strong praeverticals curving backwards and outwards . . . . . **nemea,** Mg. ♀.

Frons at vertex about one and a quarter eye width; facialia with ciliation ascending nearly to the middle; four or five frontal setae descending on to genae, and extending beyond the level of the base of arista and nearly but not quite reaching the level of the ascending facial setae; head with blackish reflections giving a dark bluish tone rather than a yellowish one; two strong praeverticals curving backwards and outwards . **vulgaris,** Fall. ♀.

18. Whitish tomentum of the abdomen covers 2nd and 3rd segments only and contrasts sharply with the all-black shining 4th segment. **confinis,** Fall. ♂ & ♀.

Whitish tomentum spread over the 2nd, 3rd and 4th segments as usual . 19.

19. Females (with the usual two outward curved fronto-orbital bristles on each side, which is characteristic of the females of all the species of this genus) 20.

Males (with no fronto-orbital setae) . . . . . 21.

20. Facialia with dense ciliation up to at least the middle; apical scutellary bristles curved upwards and forwards; small species (7–8 mm.).
roseanae, B. & B. ♀.

Facialia with only a few setae close to the vibrissaria; apical scutellary setae curved backwards and downwards; larger species (9 mm.).
westermanni, Zett. ♀.

21. With only one pair of praeverticals, the outward and backward curving bristles at the upper ends of frontal series; hind tibiae with regular comb-like ciliation on outer side; larger species (10 mm.), with a bluish-black colour tone . . . . . **hortulana,** Mg. ♂ (**blepharipoda,** B. & B.).

With two pairs of praeverticals; hind tibiae irregularly ciliated; smaller species, with a brownish-grey general colour tone . . . . . 22.

22. Abdomen with no discal setae, or but small and irregular ones.
tritaeniata, Rond. ♂.

Abdomen with discal setae . . . . . 23.

23. Scutellum black . . . . . 24.

Scutellum yellow or at least distinctly yellowish tipped . . . . . 25.

24. Facialia with dense irregular ciliation ascending at least to the middle; apical scutellary bristles curved upwards and forwards; smaller species (7 to 8 mm.) . . . . . **roseanae,** B. & B. ♂.

Facialia with no ascending ciliation; apical scutellary bristles curved backwards and downwards as usual; larger species (9 mm.).
westermanni, Zett. ♂.

25. Facialia with ciliation ascending to the middle or nearly so; frontal setae descending on to the genae in a row of five or six to below the level of the arista, so that they almost reach the level of the ascending facial bristles; head dark looking, with blackish reflections . **vulgaris,** Fall. ♂.

Facialia with ciliation ascending but little; and only about three frontal setae descending on to the genae; these do not reach the level of the

arista, and there is a considerable interval between them and the ascending facial bristles; head yellowish through yellowish tomentum.

nemea, Mg. ♂.

In this group the males throughout are without fronto-orbital setae, and the females always have two on each side.

It should be remembered that size is always apt to be an unreliable character in the TACHINIDAE, as exceptionally large or small specimens frequently occur, and are often very misleading in appearance; nevertheless, the measurements given here should be useful.

This is an extremely difficult group, and yet one of the most important, which it is very necessary to understand. The species are perhaps the most characteristic of TACHINIDAE; are frequently met with, often in abundance, and more often than any other of the genera occur as parasites to students of the Lepidoptera and other orders. They are of medium size and undistinguished appearance, nearly all being of the ordinary grey type of Tachinid. In the circumstances it will readily be understood that the nomenclature and synonymy of the species is involved, and it cannot be expected that I have used the correct names throughout. I feel sure, moreover, that my list is far from complete and that a number of British species have yet to be recognised; and must even admit that some of the names in the older British writings and in Verrall's lists may represent good and distinct species which might have been identified. Still, I think those dealt with are all the more important and commoner ones, and hope that the distinctions given may enable the species to be correctly recognised so that the names, even if they do not prove permanent, will at least mean something. To help further in this case I have thought it better to give a brief description of each species with further notes.

The species here included under *Exorista* are in the Kertesz Katalog separated into three genera: *Exorista*, *Phryxe* and *Zenillia*; but when it even proves difficult to separate these insects into species, there seem no sufficient grounds for regarding them as belonging to different genera.

hortulana, Mg. (= **blepharipoda,** B. & B.). 10 mm. long. Our largest species, much like *glauca*, Mg., but the colour tone blue-black rather than ashy-grey; it is a little larger; and its single praevertical bristle curving backwards and outwards is a good character. It has irregular discal setae; frons at vertex just about the width of a single eye in both sexes; antennae with the 3rd joint in the male four times and in the female two and a half times the length of the 2nd; lateralia equal to about one-quarter to one-fifth of the height of the eye. I have specimens from various localities, and think it will prove to be one of our commoner species.

cincinna, Rond. (= **intermedia,** B. & B.). 8 to 9 mm. long. A species very like *vulgaris*, Fall.; frons in male three-quarters of eye width; female I do not know; antennae in male with 3rd joint three times the length of the 2nd; abdomen with short and irregular discal setae; lateralia about one-quarter of height of eye; is distinguished from *vulgaris*, Fall., through scutellary apical setae curving backwards and downwards in the usual way. I have only two males from Rhayader and one from Cranham Woods, Glos., and know of no others.

confinis, Fall. 7 to 8 mm. long. A species recognisable instantly through the contrasted 2nd and 3rd tomentum-covered abdominal segments, and the black shining 4th; females sometimes have a little tomentum on the fore side angles of the 4th segment, and the contrast is not so striking. Frons at vertex

in male three-quarters of the width of one eye, in female about equal to eye width; antennae in the male with the 3rd joint seven times as long as the 2nd, in the female four times; lateralia about one-fifth of height of eye; probably not uncommon, though I have not seen many British specimens and those I have seen are chiefly from Kent and Surrey; Wye (H. Wood, ex *Lycaena coridon*, Poda.); Reigate (Dr. T. A. Chapman, ex *L. bellargus*, Rott.); Chattenden and Seal (H. W. Andrews); Tunbridge Wells (Col. C. G. Nurse), etc. J. E. Collin has recorded the breeding of a series from *Cyaniris argiolus*, L., by R. Adkin and of one from *Thecla w-album*, Kn.

fimbriata, Mg. 7 mm. long. One of the smallest species; frons at vertex in male four-fifths of eye width, in female about eye width; antennae with 3rd joint in male two and a quarter and in female one and three-quarters the length of 2nd joint; lateralia in male one-quarter, in female one-fifth eye height; abdomen with strong discals. One of the commoner species; I have it or have seen specimens from Barmouth; Tan-y-Bwlch; Studland, Dorset; New Forest; Tunbridge Wells (Col. C. G. Nurse); Frinton, Essex (Col. Nurse), etc.

glauca, Mg. 9 to 10 mm. long. Our largest species excepting *hortulana*, Mg., with which it may be confused; it is, however, not so blue in general tone, but rather a whitish grey; it has two praeverticals, the upper outward-bending frontal bristles; hind tibiae are irregularly ciliated; it is variable regarding discals, which are sometimes numerous and strong, but I think never long; frons at vertex in male three-fifths eye width and in female about eye width; antennae with 3rd joint in male two and a half times the length of the 2nd, in female one and three-quarters; lateralia one-fifth to one-sixth of eye height. The commonest of the species in the genus *Exorista* as restricted in the Katalog, commoner than any of the species here dealt with excepting *vulgaris*, Fall., and *nemea*, Mg. I have it from many localities including Scotland and Ireland.

lota, Mg. (= **immunita,** Pand.). A single male from the New Forest (1901, Dr. Sharp) was received from the University Museum, Cambridge, otherwise I do not know it, and do not possess it myself. It is distinguished from all other Exoristas by the absence of ocellary bristles and by possession of four sternopleurals; this latter character, however, is not so useful as it sounds, as adventitious fourth bristles are not uncommon in other species. It comes near to *glauca*, Mg., which it resembles rather closely; the frons is rather wider than in that species; the frontal bristles descend on to the genae in an irregular group, whereas in *glauca* they are in a simple row; there are no abdominal discals; pale palpi; reddish scutellum.

tritaeniata, Rond. (*vera, sed nec* Sch., *nec* B. & B. *teste* Villeneuve). 6 to 7 mm. long. Perhaps the smallest species; frons in male barely of eye width, in female rather more than eye width; antennae in male with 3rd joint four to five, and in female barely three times the length of the 2nd joint; lateralia one-fifth of the eye height; scutellum and palpi black. Appears to be rare. I have it from Stokenchurch, Bucks, and from Rhayader, and have also seen odd ones from the New Forest (M. A. Sharp), and Boat of Garten (F. Jenkinson). Mr. J. E. Collin tells me that Mr. A. E. Tonge bred it freely from *Callophrys rubi*, L.

westermanni, Zett. 8 to 9 mm. long. A species with rather slenderer abdomen and longer legs than is usual in this genus; frons in the male four-fifths of eye width; antennae with 3rd joint in the male five to six times the length of the 2nd; lateralia one-quarter to one-fifth the eye height; abdomen with long strong discals; face as seen in profile somewhat concave; tomentum of a yellowish tone; 3 strong frontals descending on to the genae; one pair of

recurved praevertical setae. I do not know the female.* I have two males from Torcross, Devon (Yerbury), and they are the only British specimens of which I have certain knowledge. There is an old male specimen in the Cambridge Museum, but without data.

mitis, Mg. A species very closely allied to *westermanni*. Frons in male two-thirds of eye width, in female of full eye width; antennae in male with 3rd joint three times as long as the 2nd, in female two and a half times; lateralia barely one-fifth of eye height; abdomen with discal setae; apical scutellars not recurved; tomentum rather more bluish in tone; three small frontals descend on to genae and there are a few irregular hairs beneath them; black palpi and scutellum. A single female taken at St. Ives, Cornwall, by the Rev. A. Thornley, was identified by me as this species; but it is necessary to have males to be certain, as the females of *mitis* and *westermanni* are so much alike.

agnata, Rond. 7 to 9 mm. long. Frons in the male three-fifths of eye width, in the female about same width as eye; antennae with 3rd joint in male three times and in female two and one-quarter times the length of 2nd joint; lateralia one-quarter of eye height. A species very like *vulgaris*, Fall., but easily distinguished from it by the narrow frons. I have no British specimen and have no certain knowledge of one, but feel sure it will prove British, and so have mentioned it here.

affinis, Fall. Normally about 9 mm. long, but I have small specimens a little over 5 mm. long. As previously stated, this is liable to occur with many species of TACHINIDAE, probably because of having developed some faculty of pupating as soon as the food supply is exhausted, even when the larvae are far from full grown; it is obvious that in the case of an internal parasite, unable to issue forth and obtain fresh supplies, it would be a great advantage to be able to complete its metamorphoses in this manner. Frons in male four-fifths of eye width, in female of about eye width; antennae with 3rd joint in the male two and a quarter and in female twice the length of the 2nd; lateralia in the male about one-quarter eye height and in female one-sixth. Another species closely resembling *vulgaris*, Fall., distinguished from that species by its yellow palpi, etc., by the frontal setae, which descend on to the genae in an irregular group of 7 or 8; also the tibiae tend to become rufous, but this is not always obvious. In this case also I do not really know of a British specimen, but feel sure that we have merely missed it and that it may prove a common species.

vulgaris, Fall. (**Phryxe**). (See Pl. IX, fig. 2.) 8 to 9 mm. long. A very common and widely distributed species and the one most frequently bred from lepidopterous larvae. Frons in the male one and a quarter, in the female one and a third times the width of one eye; antennae in the male with the 3rd joint five times and in the female three times the length of the 2nd; lateralia in the male about one-fifth, in the female one-quarter eye height. This species has been placed with *nemea*, Mg., and other very closely allied ones in a separate genus, *Phryxe*, but I think on insufficient grounds; its frons is certainly wide; it has some ascending setae on the facialia, but so have *roseanae*, B. & B., and others, and it has strongly recurved apical scutellary bristles, curved upwards and forwards, but so have *agnata*, Rond., *affinis*, Fall., and *roseanae*, B. & B., and I think none of the distinctions are more than specific. *Nemea*, Mg., is the closest ally, and it is often difficult to place specimens; the characters are

* I have since seen a female taken by the Rev. A. Thornley at Lamorna, Cornwall; it is not so slender as the male, but is more of the normal *Exorista* form; the antennae have the 3rd joint barely three times as long as the 2nd, and the frons is of eye width.

given in full in the tables and there is nothing I can add, but great care is necessary. *Nemea*, Mg., I think is a little smaller as a rule, and the difference in general colour tone seems a useful guide.

nemea, Mg. (**Phryxe**). 8 mm. long. Frons in male one and a fifth, in female one and a quarter times eye width; antennae with 3rd joint in male five times, in female three times as long as the 2nd; lateralia in male one-quarter, in female one-third of eye height; as common a species as *vulgaris*, Fall., and so like that species as to be separable with difficulty: see notes on *vulgaris*. It has been placed in a subgenus of *Phryxe*, named *Blepharidopsis*, but when characters of specific value are so difficult to find, there seems insufficient reason for creating separate divisions of subgeneric value for two so closely related species.

libatrix, Panz. (**Zenillia**). 9 mm. long. Frons in the male three-fifths of eye width, in the female of full eye width; antennae with 3rd joint in the male four times, in the female three and a half times the length of 2nd; lateralia in both sexes about one-quarter eye height; abdomen with distinct discals. A species covered with yellowish tomentum and therefore yellow in appearance like *excisa*, Fall.; scutellum and palpi yellow-tipped; facialia with ciliation extending halfway up; an easily recognised species from its yellow colour alone. I have a short series taken by Mr. H. W. Andrews chiefly at Chattenden, but with single specimens from Bexley and Darenth; I have also seen a female from Colchester (Harwood); another from Felden, Herts (Piffard), and various specimens in the Verrall collection from Darenth and Abbotts Wood. *Macrops*, B. & B., is, I believe, only a synonym. Dr. E. A. Cockayne has bred it from *Drepana cultraria*, F., at Horsley.

pexops, B. & B. (**Zenillia**). 9 mm. long. Frons in male fully three-quarters of eye width, in female a little wider than one eye; antennae with 3rd joint about three times the length of the 2nd; lateralia in male and female wide, equal to fully one-quarter of eye height; abdomen with distinct discals. A species easily misunderstood; placed in the genus *Zenillia* in the Katalog (8), its facial ciliae do not ascend far enough to be very characteristic, or at least not invariably, and it requires careful comparison with the typical Exoristas. In the male the face in profile suggests a "receding chin," and when this character is appreciated it will be found very useful; the vibrissaria are nearly on a level with the lower edge of the eye, and do not project to form the usual epistomal angles, but are flattened down so that the face and succiput curve into one another, giving the whole lower part of the head a convex appearance. This character is much less noticeable in the female, in which sex the other characters of frons, antennae, etc., need even closer attention.

It is a parasite of the sawfly *Nematus erichsonii*, and in 1913 Mr. J. Mangan of the University of Manchester sent me for identification a long series which he had bred from this species. The sawfly was occurring in vast numbers in various woods in the north of England, and causing serious damage. Mr. Mangan brought a number of the larvae into the laboratory for the purpose of investigation, and bred from them a number of these parasites. It is fair to assume that as so many flies were bred from the comparatively small numbers of the host brought indoors, an equal or similar proportion would occur with the vast hordes of larvae left in the woods, so that *pexops* must have existed in great numbers, possibly millions; and if so abundant in these particular woods, it must surely occur not uncommonly in many other places, and yet the only other British specimen of which I have any knowledge is an odd female taken by me in the New Forest! It has longer legs than most Exoristas.

(I have since seen an odd male in Mr. J. E. Collin's collection labelled "Ormesby, 28/6/88," and another sent to me by Dr. W. J. Fordham from Allerthorpe.)

roseanae, B. & B. (**Zenillia**). (= **Pseudoperichaeta major,** B. & B.) 7 to 8 mm. long. Frons in male three-quarters, in female of full eye width; antennae with 3rd joint in male seven to eight times, in the female five times the length of the 2nd; lateralia in male one-fifth, in female one-sixth of eye height; abdomen with distinct discal setae; apical scutellary bristles curved upwards and forwards like *vulgaris*, Fall., but although similar in appearance to that species it is easily distinguished; it is smaller and blacker, with quite black scutellum and palpi, and the long antennae are characteristic. Not uncommon. I have specimens from Eastbourne, New Forest, Barmouth, and Herefordshire, and have seen others from various localities. Mr. R. Adkin has bred a number from *Tortrix pronubana*, Hb.

18. **Phryno**, R.-D.

vetula, Mg., the only British species; a fairly common and distinct one. It is covered with yellowish tomentum, has almost entirely yellow legs, and a little yellow about the base of the antennae, etc.; it is rather larger and more robust than most of its immediate allies, being about 10 mm. long. Antennae long, 3rd joint about six times the 2nd, 2nd bright yellow; frons widish, nearly of eye width in male; abdomen with discal as well as marginal setae.

19. **Pelmatomyia**, B. & B.

phalaenaria, Rond., the only species; appears to be rare. I have odd specimens from the New Forest, Torquay and Newquay; Mr. J. E. Collin has others from Barton Mills near Newmarket, and Ivybridge, and I have seen it from Mansfield, Notts (Prof. Carr). It may like many other species prove to have been overlooked, and to be common enough, as it is an undistinguished species of the most typical Tachinid appearance, and would be readily passed over as some common species. It is not unlike *Nemorilla*, Rond., in size and general appearance, but is most closely allied to *Carcelia*, possessing nearly all the main characters of that genus; but it looks different; it is darker; its abdomen is narrower, and with longer legs it seems a slenderer insect altogether. Though looking like a *Nemorilla* it is readily distinguished by its longer antennae, the 3rd joint being three or four times the length of the 2nd, and by the absence of any denticulate markings on the abdomen.

20. **Nemorilla**, Rond.

There were supposed to be two species in this genus, **floralis,** Fall., and **maculosa,** Mg., but it is very doubtful if they are really distinct, and indeed it is almost impossible to decide to which many individuals should be assigned. I have succeeded in dividing my numerous specimens into two lots, and am inclined to call them *floralis*, Fall., and var. *maculosa*, Mg. The characters upon which I have relied are (1) the proportionate lengths of the 2nd and 3rd antennal joints; in *floralis* the 3rd is markedly longer than the 2nd, perhaps half as long again; while in *maculosa* it is only a little longer. (2) *Floralis* has, I think, a slightly narrower frons and perhaps narrower lateralia too, which might be expressed otherwise by saying that it has larger eyes which occupy rather more of the head. (3) The abdominal markings differ, but are very variable, and there are many intermediates; as a rule, however, the dark

markings on the 2nd segment are distinctly separated into three dentate spots in *maculosa*, whilst in *floralis* they are usually coalesced into a tridentate band.

All my British specimens seem to be typical *floralis*, Fall. (= *notabilis*, Mg.), but although I have seen no British representative of what I call *maculosa*, Mg., yet the name occurs in various lists and it may well occur here. *Floralis*, Fall., is one of our common species and is soon recognised by its long slender legs, dark tridentate abdominal markings, and its golden-brown tomentum; it has a lengthened 2nd antennal joint, the 3rd joint being only about half as long again; hind tibiae regularly ciliated; narrow lateralia. Stein (24) and Lundbeck (28) have both sunk *maculosa* as a synonym of *floralis*, making a single species.

21. **Epicampocera**, Macq.

1. A bluish-black insect with palpi black; antennae with 3rd joint large, quite three times as long as the 2nd, and in profile the front is seen to be conspicuously curved convexly, strikingly so in the male, less markedly so in the female . . . . . **succincta,** Mg.
2. A brownish insect, with yellow palpi; antennae with smaller 3rd joint, less than twice as long as the 2nd, and normal in shape, that is to say straight in front . . . . . **conspersa,** Mg. (= **ambulans,** Mg.).

Two readily recognisable species of medium size and typical Tachinid appearance, both fairly common and well known, and especially characterised by their hairy genae. I have no records from Scotland, and only one of *succincta* (Stradbally, H. W. Andrews) from Ireland; but they are widely distributed and probably occur throughout the country.

22. **Masicera**, Macq.

1. ♂. Antennae large, long, black, reaching to the epistomal edge; 3rd joint fully five times as long as the 2nd; female frons but little wider than one eye . . . . . **silvatica,** Fall.
2. ♂. Antennae smaller, brown, not reaching to the epistomal edge; 3rd joint barely four times as long as the 2nd; female frons seen from above quite one and a quarter times eye width . . . . . **pratensis,** Mg.

These two large stout species are common in many places on the Continent and have crept into British lists, but I have never seen a British specimen. I have included them here because it is so likely that they will be found in this country. They belong to the bare-eyed group with irregularly ciliated hind tibiae, amongst which their size and general robustness distinguish them.

23. **Ceromasia**, Rond. (*sens. lat.*) *et*

24. **Lydella**, R.-D.

1. Fourth longitudinal wing-vein at the bending near to the hind margin, fully twice as far from the hinder cross-vein as from the margin; the bending rounded (see *Microvibrissina muscaria*, Fall.). **Ceromasia sordidisquama,** Zett.

   Fourth vein at the bending about equidistant from the hinder cross-vein and the hind margin, maybe a little nearer the hind margin, but not much. . . . . 2.
2. A yellow-looking insect through being covered with yellowish tomentum; tibiae yellow; palpi wholly yellow . . . . **Lydella ferruginea,** Mg.

   An insect of the usual blackish-grey colour, with whitish tomentum; tibiae black, and palpi at most lighter tipped . . . . . 3.

3. Frons wide; as seen from above, at vertex about one and a quarter times the width of one eye in both sexes; arista thickened for the greater part of its length; antennae in male long, with the 3rd joint four times the length of the 2nd, in the female only about twice to two and a half times; four dorso-central pairs of bristles behind the suture; claws short in males . . . . . **Paraphorocera senilis,** Mg.
Frons at vertex not more than eye width or less (excepting in the female of *stabulans*, Mg., in which it is a shade wider than the eye) . . . 4.
4. Antennae in male with the 3rd joint three times the length of the 2nd, in female barely three times; three dorso-centrals behind the suture; frons in the male two-thirds of the width of one eye, in female about equal to eye width; no apical scutellary bristles, only the usual three pairs of marginal ones; usually rather larger than its nearest allies; a long-bodied, slender species . . . . . **Lydella albisquama,** Zett.
5. Antennae in the male and female with 3rd joint only about half as long again as the 2nd; three dorso-centrals; no apical scutellary bristles; frons in the male about three-quarters of eye width, in female barely of eye width; female with edges of tergites meeting beneath in a serrate edge, the hind angles of each segment projecting and bearing strong short setae; the male shows slight signs of the same thing, but in that sex it is easily overlooked (see *Microvibrissina* with similar female). **Lydella nigripes,** Fall.
6. Antennae in male with 3rd joint two and one half times as long as the 2nd, in the female one and three-quarter times; frons in male of eye width, in female a little over eye width; four dorso-centrals; scutellum with a pair of apical bristles in addition to the usual three pairs of marginal ones; claws in males lengthened; a species closely resembling *senilis*, Mg., but with shorter antennae, and arista only thickened at the base . . . . . **Lydella stabulans,** Mg.

This is a group of bare-eyed species of characteristic Tachinid type, similar to, and contrasting with the *Exorista* group which contains hairy-eyed species.

Four of the above six species are amongst the commonest of our TACHINIDAE, and are found in most collections however small. They are typical TACHINIDAE in appearance, and are very like one another and resemble a number of other common species, so that close observation is necessary for correct identification. They have probably been recorded and listed under a number of names, but it would be almost impossible to settle all the synonymy. *Ferruginea*, Mg., is fairly easily recognised through its general yellowness; *Erycia fatua*, Mg., is very similar, but has no discal setae. *Ferruginea* is rare; I have it from Rhayader, Logie, N.B., and Upper Arley, Worcestershire, and have also seen specimens from the Doward, Herefordshire (Dr. J. H. Wood), and Bomere, Salop (H. Bury), but only singly. *Albisquama*, Zett., is even rarer apparently, as I have only seen one male from Bishop Auckland (Rev. W. J. Wingate), which I identified as this species with some doubt when I saw it a long while ago. It is so easily confused with the other species, especially with *sordidisquama*, Zett., that it needs confirmation before being definitely admitted to the British List. *Sordidisquama*, Zett., is one of three or four species which sometimes occur together in woods in great numbers at the end of May and beginning of June: others being *Phorocera caesifrons*, Macq., *Lypha dubia*, Fall., and *Meigenia floralis*, Fall. Three of the species, *sordidisquama*, Zett., *albisquama*, Zett., and *nigripes*, Fall., possess only three dorso-centrals, and no apical scutellary bristles, that is to say, have only three pairs of marginal setae, not four.

25. **Microvibrissina,** Villen.

This genus was created for **muscaria,** Fall., a species of uncertain position, which seems to have been little understood and to have led to some confusion. Even now its relationships are doubtful, although I favour placing it with the *Ceromasia* group; in the Katalog (8), however, Bezzi puts it into the genus *Degeeria* far away from *Ceromasia*, and it has been otherwise associated with the *Degeeria* group. It is one of those species which it is desirable to have in both sexes, when its identification becomes easy and certain, though I think that the characters given in the tables should enable the separate sexes to be named. It is a very similar species to *Ceromasia sordidisquama*, Zett., and may easily be found mixed with it. In the male sex the greater width of the frons and the possession of fronto-orbital setae by *muscaria* is sufficient distinction, and indeed this character separates it from all the species of the *Ceromasia* group, and all those of the *Degeeria* group equally, including *Vibrissina turrita*, Mg., with which it has been much mixed; Verrall's record (*E.M.M.*, 1912, p. 191) of that species was based upon specimens of *muscaria*. The female is one of those distinguished by the possession of a serrated underside; others being *Lydella nigripes*, Fall., *Compsilura concinnata*, Mg., and the species of *Vibrissina*. I do not think *Vibrissina* is British; it appears to have the facial setae ascending higher than in *muscaria*, up to nearly three-quarters of the height, and the serrated underside, judging by the only specimens I have seen, is only slightly developed, but it and *muscaria* are very much alike in the female sex. *C. concinnata* is a well-characterised species with its sickle-like ovipositor and strong facial setae, and *L. nigripes*, Fall., can easily be distinguished; it is blacker and more robust; the first posterior wing-cell in *muscaria* reaches the wing-margin almost at the tip; in *nigripes* it is some distance away from the tip; also the antennae in *nigripes* are shorter, the 3rd joint being only about one and a half times the second, whilst in *muscaria* it is about two and a half times; also *nigripes* has practically no ascending facial setae, and in *muscaria*, though not strongly developed, they do reach the middle of the face.

I have *muscaria* from the New Forest and Wyre Forest, and have seen odd specimens from Crowborough (F. Jenkinson); Middle Park, Herefordshire (Dr. Wood); Herts (Piffard), and a series from Tubney near Oxford taken by Mr. J. Collins.

26. **Erycia,** R.-D.

Fatua, Mg. The only British species; already referred to as being similar to *Lydella ferruginea*, Mg., with which it has been greatly confused; in the male the short claws as well as the absence of abdominal discal setae will enable it to be recognised; in the female close observation is required, but the absence of discal setae should distinguish it. Mr. A. H. Hamm sent me three males to examine; they had been bred from Cornish *Melitaea aurinia*, Rott., in 1920, and that is all I know about it as a British species.

27. **Bactromyia,** B. & B.

One species only, **aurulenta,** Mg. A small species belonging to the group with bare eyes, and easily overlooked amongst the common species of *Ceromasia*, etc. It has no, or only feeble, discal macrochaetae; the bending of the 4th longitudinal wing-vein is rounded and twice as far from the hinder cross-vein as it is from the hind margin, in which respect it resembles *Ceromasia sordidisquama*, Zett., alone; *sordidisquama* has two pairs only of praesutural

acrostichals and *aurulenta* has three pairs; in *aurulenta* the male antennae have a long 3rd joint and very short 2nd one, the former being quite six times the length of the 2nd; the female having the 3rd joint nearly four times the length of the 2nd; in *sordidisquama* the 3rd joint is much shorter; there are four dorso-centrals. It seems to be a rare species; I have only one specimen from West Hide near Hereford, and one from Wyre Forest, and have seen a few others from Timworth, West Suffolk (Col. Nurse); the New Forest (G. T. Lyle and R. C. Bradley); Laughton (Verrall Coll.), etc. Mr. Collin has one bred by Dr. Cockayne from *Thecla w-album*, Kn.

28. Ptychomyia, B. & B.

Selecta, Mg., the only species. This is the first of a series of genera distinguished by the increased development of the facial setae, which are usually long and strong and extend to the middle of the face or beyond. *Selecta* is a small species; in its typical form it has discal abdominal setae; but numerous examples occur without these discals, and they were at one time regarded as constituting a distinct species under the name *Prosopodes fugax*, Rond.; actually at most they form but a variety of *selecta*. It has incurved hind-marginal cross-vein, with slight cubital appendage; very long antennae; 3rd joint in male fully eight times the 2nd. It is not common. Dr. J. H. Wood took it in various localities in Herefordshire, and I owe most of my specimens to him. I also have it from Wyre Forest (var. *fugax*), and have seen it from Sherwood Forest and other localities in Notts (Prof. Carr); the New Forest; Tunbridge Wells (Col. Nurse); Felden, Herts (A. Piffard); West Suffolk (Col. Nurse); Bishop Auckland (Rev. W. J. Wingate), etc.

Mr. J. E. Collin has called my attention to the fact that a short series of this species bred from *Yponomeuta* (*padellus*, L.?), and now in his collection; all wanted the discal setae; whilst another series bred by Mr. E. E. Green from sawfly larvae found on birch at Camberley all possessed the discals. This may be pure chance, but it seems worth recording in case some other and sound distinction between the two forms may be discoverable, and possibly the one prove a parasite of Lepidoptera and the other of phytophagous Hymenoptera.

29. Staurochaeta, B. & B.

Albocingulata, Fall. (= **gracilis,** Egger). Again a single species only. I know almost nothing about it. It has been recorded as British (see Morley, *Entom.* 1906, p. 273), but confirmation seems desirable, and I have not myself seen a British specimen.

30. Frontina, Mg.

Laeta, Mg. A well-known species on the Continent, but doubtfully British. There is a specimen in Mr. Verrall's collection labelled "bought from Saunders," and there are two old specimens in the British Museum without data; I have not seen or heard of any other British capture, and it is a case where confirmation is again desirable. Being a good-sized, well-distinguished species it is not likely to be readily overlooked. It is a luteous species not unlike *Micropalpus vulpinus*, Fall., in appearance; the abdomen largely yellow; very strong facial setae, and antennae with 3rd joint very long in comparison with the short 2nd.

31. Erynnia, R.-D.

One British species, **nitida,** R.-D. This is extraordinarily like *Anachaetopsis ocypterina*, Zett., both being very small shining black species agreeing in

nearly every character, the long-stalked hind-marginal cell, long antennae, facialia ciliated two-thirds of the way up, etc., but in the male easily separated because *nitida* has no fronto-orbitals and *ocypterina* has two strong ones each side. The females require close observation; the antennae in *nitida* are, however, shorter, the 3rd joint scarcely as much as three times as long as the 2nd, whilst in *ocypterina* females it approximates four times; *nitida* has no marginals on the 1st visible abdominal segment, and *ocypterina* has strong ones; and *ocypterina* has small apical scutellary setae, of which there is no trace in *nitida*; also palpi in *ocypterina* are definitely dark and in *nitida* tend to paleness. My attention was called to the species by Mr. Collin, who has a short series taken chiefly at Barton, Suffolk, but some also at Tuddenham.

32. Hypochaeta, B. & B.

Only one British species, **inepta,** Mg. (= **distincta,** Mg. = **longicornis,** Sch.), a smallish grey species of typical Tachinid appearance with bending of 4th vein curved, not angulated; 3rd antennal joint five times 2nd; abdomen with discal setae. Not common; I have it from Wyre Forest, Rhayader, and Aviemore, and have also seen it from Rannoch (a small series in Mr. Verrall's collection) and Beattock. These Scotch records suggest that it may be a northern insect and perhaps common there.

33. Campylochaeta, Rond.

Again one species only, **praecox,** Mg. (= **obscura,** Fall.), and not common. This seems to be an early spring insect and possibly not so rare, but overlooked through being on the wing before collectors are about much. I have found it on the sallows at Wyre Forest, and also have specimens from Chattenden (H. W. Andrews), Wood Ditton Wood (J. E. Collin), and have seen others from Monkswood (Col. Yerbury), and Chingford (Col. Yerbury). Its recurved ocellary bristles are an unusual and distinctive character; it has large and exposed genitalia in male; some hairs on upper part of genae; and long antennae with 3rd joint seven or eight times the length of the 2nd.

34. Diplostichus, B. & B.

Janithrix, Hart. The only species. Very closely allied with *Tricholyga sorbillans,* Wied, and *Parasetigena silvestris,* R.-D., with which species it may have been mixed hitherto; the characters given in the table should enable identification to be effected. I have seen three males from the New Forest: one taken by Dr. Sharp in 1901, and two bred by Mr. G. T. Lyle from cocoons of *Lophyrus pini,* L., in 1910; Mr. J. E. Collin has three specimens bred from sawflies by Mr. E. E. Green, and a male from Parley Heath, 2.ix.05.

35. Compsilura, Bouché.

Concinnata, Mg. (= **Machaira serriventris,** Rond, etc.). A common and well-known species. The female has the central line of the underside of the abdomen developed so as to be distinctly saw-like, a character also possessed by the females of *Lydella nigripes,* Fall., and *Microvibrissina muscaria* (Fall.), Mg., and also the species of *Vibrissina.* From all these *concinnata* can be easily distinguished by the well-developed facial setae, which ascend the facialia for the greater part of their length. It also has a conspicuous sickle-shaped ovipositor. The male has no trace of the saw-like structure, and is

therefore less well characterised, but the entire absence of ocellary bristles, and the bending of the 4th longitudinal vein, which is very rounded and near to the hind margin, will help towards recognition; it is a medium-sized fly of light grey coloration. I have seen specimens from many localities, all, however, in the southern half of England, King's Lynn and Mansfield, Notts, being furthest north; I expect, however, that this occurrence is due to chance, and the species will prove to be common throughout the kingdom. It is one of the best-known parasites of lepidopterous larvae, and has been bred from a great number of species.

36. PALES, R.-D.

Pavida, Mg. (= **cilipeda,** Rond.). Another common and well-known species; rather stout, of fair size and bluish coloration, with its strong facial ciliation it is readily recognised. It has long black antennae with 3rd joint four to five times as long as the 2nd; black palpi; four D.C.; crossed apical scutellars, and discals on abdomen; tomentum on the abdomen distinctly bluish. Not so common as the last, I have, however, seen it from a number of localities including Scotland.

Pumicata, Mg., is supposed to be a distinct species and Mr. Verrall had specimens so named in his collection, but I have up till now failed to distinguish it from *pavida.* The hind tibiae of *pavida* are supposed to be evenly ciliated or comb-like, with just one large bristle only; whilst those of *pumicata* are described as irregularly ciliated, with several large bristles, but I have not been able to satisfy myself about this or any other distinction.

37. PARASETIGENA, B. & B.

Silvestris, R.-D. (= **media,** Pand. = **segregata,** B. & B.), the only species, closely resembling *Diplostichus janithrix,* Hartig, and *Tricholyga sorbillans,* Wied, the distinctions being dealt with in the table very carefully. I have one male only from the New Forest, and have seen four females also from the New Forest which are in the Cambridge Museum and which I think were this species, and Mr. Collin has another female also from Lyndhurst.

38. PHOROCERA, R.-D.

1. Larger species, with the indentation of the 1st visible abdominal segment reaching to the hind margin; 4th sternite with distinct projection in middle of hind margin; scutellum more or less reddish . **assimilis,** Fall.
2. Smaller species, with the indentation of the 1st segment not nearly reaching the hind margin; 4th sternite with the hind margin evenly rounded, with no projection; scutellum darker, only occasionally a little red at the apex . . . . . **caesifrons,** Macq.

For some time past these two species have been regarded as being one only, variable in size, but with the large specimens differing in no other respect, and representing nothing more than that tendency to variation in size which is so frequent in this family of insects; *assimilis* being the older name had in those conditions to be used for the species, and the smaller and commoner forms were called var. *caesifrons.* In his recent book Lundbeck (28), however, calls attention to the above-mentioned characters, which seem quite good and reliable, and I follow him therefore in regarding them as two good species.

The insects of this genus are of typical Tachinid appearance, but easily recognised in the male sex not only by the ciliated facialia, very hairy eyes, and

other characters mentioned in the tables, but also by its large projecting genital segments, which are very conspicuous; and in the female sex the abdomen is curved or humped in a characteristic manner, through the shortening of the ventral segments, etc., and the apical sternite is inflated and striate, and thus very distinctive. The antennae are of medium length, the 3rd joint about four times the length of the 2nd in the male; the chaetotaxy is strongly developed, there are abdominal discals, etc. *Assimilis* seems rare; I have three males and one female from the New Forest, and have notes of other large specimens seen which are probably this species, but I cannot now be certain. *Caesifrons* is one of our commonest species. It sometimes occurs in abundance with other common species in woods in the spring, about the beginning of June, but I do not happen to have seen specimens from Scotland or Ireland. It varies greatly in size, the great majority of the individuals being round about 7 or 8 mm. in length, but even smaller ones occur, and occasionally much larger ones up to 10 mm. or even more; *assimilis*, however, running from about 10 mm. to 12 mm. The larger specimens closely resemble the group of species in the genera *Parasetigena*, *Tricholyga*, and *Diplostichus*, and again the characters given in the tables require close attention.

39. Mystacella, Wulp.

Majuscula, Rond. Some years ago I saw two males from Ranscombe taken on Oct. 11, 1866, on ivy, and a female from Malling Hill, Lewes, taken on Oct. 27 in the same year, all from Mr. Verrall's collection, which I identified at the time as this species, but I have no other knowledge about it. The late date of captures suggests that it may be a late autumn species which gets overlooked through the small number of collectors who are out at that season. It should be easily identified as being like a *Meigenia* but with hairy eyes.

40. Meigenia, R.-D. (See Pl. IX, fig. 3.)

The two species of this genus **bisignata,** Mg., and **floralis,** Fall., are difficult to distinguish from one another, and I am by no means sure that they are not really one species only. Some individuals of the two seem far apart, but intermediates occur, and there are many specimens which it is difficult to place. Size, a most unsatisfactory character, is the chief one, typical *bisignata* being much larger than typical *floralis*; *bisignata* being about the size of the common housefly, and *floralis* much smaller. *Bisignata* most frequently has only one pair of dark markings on the abdomen, on the 2nd segment; whilst *floralis* almost always has two pairs, on the 2nd and 3rd segments. *Bisignata*, however, sometimes also has the two pairs (= var. *quadrimaculata*, Macq.), and sometimes none at all (= var. *immaculata*, R.-D.). The markings of *floralis* are usually joined together at the base, more or less, thus forming something of a band; its antennae are supposed to be shorter than those of *bisignata*; perhaps the frons is a little narrower; perhaps too *bisignata's* abdomen is a little more setigerous than that of *floralis*; but I have never been able to satisfy myself with any of these distinctions. The species can be recognised fairly easily through their characteristically shortened face (see Pl. IX, fig. 3), and abdominal markings; further, in the male sex the vertical bristles are thin and almost hair-like, and the antennae also are thin, the 3rd joint about three times the 2nd; the female is of ashy-grey coloration, with the abdominal markings not so well developed; both sexes have recurved apical scutellars. *Floralis* is very common, and is one of those species which sometimes occurs

in great abundance in woods in the spring, about the beginning of June; *bisignata* I have never seen in numbers, but it is widely distributed. I do not happen to have seen specimens of either species from Scotland or Ireland. Stein (24) considers that there is but one species, and he calls it *mutabilis*, Fall., and Lundbeck (28) follows him.

41. VIVIANIA, Rond.

One species, **cinerea,** Fall., a whitish-grey rather small insect, apparently rare. Rather like an immaculate *bisignata*, Mg., but without discals and without apical scutellars. It has the characteristic face of the Meigenias. I have one male only from Greenwich Marshes (H. W. Andrews). In the British Museum is a series of fourteen or fifteen specimens from Felden, Herts (A. Piffard and E. E. Austen), otherwise I have seen only a few odd ones: Upware (Verrall coll.), Herefordshire (Dr. J. H. Wood), Porthcawl (Yerbury), Newmarket (Verrall coll.).

42. TACHINA, Mg. (See Text-figs. I to IV.)

1. Three postsutural D.C. on thorax; scutellum usually black; male with a red brush of hairs on the genitalia . . . . . 2.
   Four postsutural D.C. on the thorax; scutellum usually more or less fulvous; male with no red hairs on the genitalia . . . . . 3.
2. Abdomen with discal as well as marginal macrochaetae on the central (2nd and 3rd) segments . . . . . **(Chaetotachina) rustica,** Mg.
   Abdomen with only marginal macrochaetae . **(Microtachina) erucarum,** Rdi.
3. Facial setae ascend halfway up the facialia and reach to the level of the descending frontal setae; face and frons blackish grey; frons at vertex about eye width in male, and in female wider still, perhaps one-quarter wider . . . . . **fasciata,** Fall.
4. Facial setae do not ascend quite so far, and there is an obvious gap between them and the descending frontal setae; face and frons with golden-yellow tomentum; frons at vertex narrower than in *fasciata*, Fall., being less than eye width in the male and about eye width in the female . . . . . **(Tachina** s.s.**) larvarum,** L.

Another genus of very common insects, absolutely the typical species of the family. They are well-known parasites of many species of Lepidoptera and are often bred by students of that order; the antennae are rather characteristic, the 2nd joint long, the 3rd only about half as long again; the frontal setae are long and strong and descend on to the genae rather conspicuously; the 1st posterior cell reaches the costa some distance before the wing-tip. Again the species are extremely variable, and endless names have been given to the various forms; and yet I believe there are but very few distinct species; indeed I am inclined to think that even my short list of four given above is too long, and that there are really only two distinct British species, namely *larvarum*, L., and *rustica*, Mg. In the *Katalog der Pal. Dipteren* twenty pages are given to this genus and nearly the whole of the names on those twenty pages will probably prove to be but synonyms of these two, even two subgenera, *Chaetotachina* and *Microtachina*, being probably based on forms of the one species *rustica*, of which *erucarum* is apparently but an occasional variety in which the abdominal discals fail. Besides those in the table, *nigricans*, Egger, is a small dark form of *rustica* with fewer frontal bristles descending on to the genae, there being only three or four below the antennal bases instead of the five or six to be found in larger, more robust individuals

which I should regard as being typical; further, *nigricans* shows little of the yellowish tomentum which is usually conspicuous on the abdomen of typical *rustica*. *Nigricans* is a common British form. *Glossatorum*, Rond., is, I suspect, another form of *rustica* in which there are four D.C.

43. TRICHOLYGA, Rond.

Sorbillans, Wied (= **major,** Rond.), the only British species; a large fly closely allied to and resembling *Tachina*, but easily separated by the hairy eyes. The venation as in *Tachina*; frontals strong and descending and reaching to ascending facials; 3rd joint of antennae twice the length of 2nd; no abdominal discals. Like *T. rustica*, Mg., it has a brush of red hairs on the male genitalia, a character which so far as I know is confined to these two species and their various forms. It is a parasite of *Saturnia pavonia*, L., from which it is frequently bred. As mentioned apropos of *Diplostichus janithrix*, Hart., that species and *Parasetigena silvestris*, R.-D., closely resemble this species, and the three hitherto have not been well distinguished, although the characters given in my table should enable them to be identified, and the above-mentioned red bunch of hairs would sufficiently differentiate *sorbillans*, Wied, ♂ from the others. This is the commonest of the three species, and probably occurs wherever its host does.

A further species, *Tricholyga segregata*, Rond., may also occur in this country and be mixed with one or other of this little group of species, and although it has not yet been found I have included it in the table so that if it should be it may be recognised.

44. STOMATOMYIA, B. & B.

One species only, **acuminata,** Rond. Two male specimens of this species taken by A. Piffard at Felixstowe on the 11th and 25th August, 1896, and now in the British Museum collection, were submitted by me to Dr. Villeneuve and identified by him. This is all I know about it as a British insect, and it seems generally rare and little known; it is a small and inconspicuous species and easily overlooked. Its projecting beak-like epistoma is characteristic. Apparently the eyes vary, being sometimes definitely hairy and sometimes almost if not quite bare. The first posterior wing-cell ends far from the wing-tip; there is a long cubital appendage at the bending of the 4th longitudinal; the 3rd vein bears setae at the base to beyond the discal cross-vein; there are strong facial ciliae ascending nearly to the arista.

45. PERICHAETA, Rond.

Unicolor, Fall., the only species; a medium-sized black and shining insect, with dense and characteristic setose pilosity. The frons is wide, even in the male more than eye width, with, in addition to two fronto-orbitals, one outward-curved praevertical bristle on shining frontorbita; the prominent epistoma and strong facial setae ascending most of the way up are characteristic. It is uncommon; I have it from Lynton and Torquay, and have seen it from Holne (Yerbury), New Forest (G. T. Lyle), Glengariff (Yerbury), and Ivybridge (Verrall coll.).

46. MONOCHAETA, B. & B.

One species, **albicans,** Fall. (= **leucophaea,** Mg.). One of our common species occurring freely in woods in the spring. Its single fronto-orbital bristle in both sexes enables it to be fairly easily recognised as a rule; specimens,

however, occur with the more usual two bristles, when it is not so easy. It is clothed with a dense ashy-grey tomentum, with brown hind margins to the abdominal segments, fine brown lines on the thorax, and reddish frontalia, all of which contrast with the grey; the tibiae are partly reddish; frons wider than eye width; antennae long, in the male the 3rd joint is six times as long as the 2nd; 3rd longitudinal vein bends forward in a rounded curve, near to the hind margin; three D.C.; no apical scutellary setae; abdominal discals present.

47. **Brachychaeta**, Rond.

Strigata, Mg. (= **spinigera,** Rond.). A little-known species, perhaps because it is on the wing very early in the spring, my specimens having been taken in April or early May. Its long black antennae, with the 3rd joint about seven times as long as the 2nd, the arista thickened nearly to the tip, ascending facial setae, small eyes and therefore wide genae and lateralia, the former nearly as broad as the eye itself, the 1st posterior cell reaching the costa a long way from the wing-tip, with no cubital appendage at the bending of the 4th vein, are characteristic. I have odd specimens from Wyre Forest, Malvern (Col. Yerbury), and Coleshill, and have seen one from Mildenhall (C. G. Lamb), and a series in the British Museum taken by Piffard at Felden, Herts, between March 31st and April 5th. Mr. J. E. Collin also has odd ones from Monks Wood, Felden and Aviemore.

48. **Histochaeta**, Rond. (See Pl. X, fig. 11.)

Marmorata, F. (= **vertiginosa,** Fall.). A fairly distinctive species with its somewhat swollen face into which are sunk the very long antennae, and the row of strong setae on nearly the whole length of the facialia. It is not uncommon, and I have notes of its occurrence in a number of localities including Ireland, Glengariff (H. W. Andrews) and Valencia Isle (Yerbury).

49. **Germaria**, R.-D.

Ruficeps, Fall. This is a rather striking and distinctive fly, which forms the subject of one of Curtis' beautiful plates in his *British Entomology*, and has long been included in lists of British Diptera. The only specimens that I have seen which might be British are two in the Verrall collection without labels. I suspect that these may be the actual specimens referred to by Walker in the *Insecta Britannica* as being in the Desvignes collection, as I believe that Mr. Verrall purchased some of the Desvignes Diptera, but in any case their origin remains doubtful. Curtis, however, gives very exact particulars of the capture of two specimens, one near Dover and one near Yarmouth, so that it seems as if the species has been found in this country, and if so it may be found again when the right place is discovered.

Angustata, Zett. There is a specimen of this rare species in the late Mr. Verrall's collection taken at Martham 26.vi.88, and recorded by him in *E.M.M.*, 1911, p. 79. Thanks to Mr. J. E. Collin I have had an opportunity of re-examining this specimen, which is a male in good condition, and unmistakable. It is very different from *ruficeps*, being altogether a smaller insect, about 6 mm. long, black with some pruinosity and but little rufous about it; the arista presents the most marked feature, being thickened throughout and the 2nd joint even a little longer than the 3rd; the wing shows short rows of setae on the basal halves of the 1st and 3rd longitudinal veins, in the latter case nearly reaching to the small cross-vein, and apparently there should be about three bristles on the outer half of the 2nd longitudinal, but those are missing in

Mr. Collin's specimen. *Ruficeps* has a very prominent profrons, the genae at this point being as wide as the eye; in *angustata*, however, the profrons is not specially produced and the genae at that point only half eye width. It is apparently a littoral species or at least frequents sandy places, and might be searched for in such localities. Stein ascribes it to a separate genus, *Atractochaeta*, B. & B., and perhaps this is desirable.

50. Gonia, Mg.

1. Abdomen all black . . . . . 2.
   Abdomen with broadly rufous sides . . . . . 3.
2. Abdomen with no whitish tomentum, or at least not sufficient to form a definite whitish margin to each segment . . . . . **foersteri,** Mg.
   Abdomen with conspicuous whitish margins to front of each segment. **fasciata,** Mg.
3. Abdomen without whitish tomentum or at least not sufficient to form a definite whitish margin to each segment . . . . . **divisa,** Mg.
   With conspicuous shining white fore margins to the abdominal segments. 4.
4. The dark band down centre of abdomen widish, more than half as wide as the rufous sides; darker-looking insects . . . . . **ornata,** Mg.
   The dark band narrow, the rufous sides being three or four times as wide; the whole insect looking brighter and lighter in colour . . . **capitata,** Deg.

A genus of distinct and rather conspicuous flies, large and stout, with characteristic swollen-looking faces. The fronto-orbits and genae bear many bristles or strong hairs in several disordered rows; the arista is thickened almost to the tip and the 2nd joint nearly as long as the 3rd; antennae are long. *Fasciata*, Mg., is an early spring species, apparently associated with Hymenoptera, and I once saw it in numbers during a short spell of hot sunshine near Ventnor. Appearing as it does at a season when bad weather is the rule, it may be that it is overlooked owing to the rarity of moments sunny enough to induce it to fly about. *Foersteri*, Mg., is a rare Britisher. There is a fine specimen in Mr. Verrall's collection labelled "nr. Plashett, Lewes, 1/4/71," but I know of no other. Of *divisa*, Mg., I have specimens or records from several localities in the south, some of them dated as early as March 16th, so that it also may be overlooked through its early appearance. *Ornata*, Mg., is, I think, the commonest of the genus, but that may be due to its season being May and June, when it is more likely to be seen. It seems to be especially attached to sandhills on the coast, as most of my records are from such localities: N. Sutor, Cromarty (W. R. O. Grant), Nairn (Yerbury) to St. Ives, Cornwall. Col. Yerbury took it in abundance at Barmouth. *Capitata*, Deg., is not certainly British, I have no record and know of no British specimen, but it occurs in lists and is such a widely distributed species that I should expect it to occur here, and it may easily get mixed up with *ornata*, Mg., which it is very like. *Ornata* is not only darker but has much more whitish tomentum, and side by side the colour differences are distinct enough.

51. Voria, R.-D.

1. Abdomen without discal macrochaetae . . . . . **ruralis,** Fall.
   Abdomen with discal macrochaetae . . . . . 2.
2. Black palpi; three or more of the large strong genal setae are curved downwards, though one may be comparatively small and weak. **trepida,** Mg.
   Pale palpi; usually only one or two downward-curved genal setae, but possibly one or two fine hairs besides . . . . . **curvinervis,** Zett.

A genus of flies of typical Tachinid appearance, but easily recognised by the unusually sloping postical cross-vein, which contrasts with the more upright hinder cross-vein; also by the frontal bristles, which are few in number but unusually strong and large, and descend on to the genae, where at least one at the bottom is curved downwards instead of upwards like the rest. They are common and widely distributed. *Curvinervis* is very doubtfully distinct from *trepida* and specimens are frequent which can be placed with difficulty.

52. Anachaetopsis, B. & B.

At this point begins a series of genera all containing species of small size and this one of the smallest, **ocypterina,** Zett. A shining black species distinct and easily recognised by the row of setae on the facialia and the stalked 1st posterior cell. It is not uncommon and is probably overlooked on account of its small size, so that it may prove to be quite common. I have seen it from a number of localities, and it is widely distributed. See *Erynnia nitida*, R.-D., which it closely resembles, for a comparison of the two species.

53. Wagneria, R.-D.

1. Species without discal setae on the abdominal segments; with only two pairs of marginal setae on the scutellum, and only two sternopleural setae; small flies with blackened wings; with 3rd longitudinal vein setose to well beyond the discal cross-vein; small antennae, 3rd joint neither wide nor long, about three times as long as the 2nd in male and about twice in female . . . . . **nigrans,** Mg.
   Species with discal setae on the abdominal segments . . . . . 2.
2. Abdomen entirely shining . . . . . 3.
   Abdomen with whitish tomentum forming distinct bands on the segments 4.
3. Medium-sized species; 3rd longitudinal vein setose to small cross-vein only; stalk of cell as long as the apical cross-vein; with three pairs of marginal setae on scutellum; three sternopleurals, but middle one small and may sometimes fail; discal setae on 2nd visible abdominal segment sometimes small and apparently failing; antennae small as in *nigrans*; wings darkened somewhat . . . . . **costata,** Fall.
   Larger species, like *lentis*, Mg., and *succincta*, Mg., being nearly as large as *Phryxe vulgaris*, Fall., and strongly setose; 3rd longitudinal vein setose well beyond the discal vein; stalk of 1st posterior cell a little more than half the length of the apical cross-vein, which is incurved; antennae large, 3rd joint in male quite five times as long as the 2nd; wings clear; three strong sternopleurals . . . . . **latifrons,** Zett.
4. First posterior cell with a short stalk, barely one-quarter of length of apical cross-vein, which is strongly incurved; postical cross-vein nearer to bending of the 4th longitudinal than to the discal cross-vein; 3rd longitudinal setose to discal vein only; large species with clear wings, and large antennae in male, 3rd joint being five times as long as the 2nd, in female only about two and a half times . . . . . **lentis,** Mg.
   First posterior cell with long stalk, as long as the apical cross-vein, which is straight; postical cross-vein midway between discal cross-vein and the bending of the 4th longitudinal; white tomentose bands narrower than in *lentis*, but still distinct; 3rd longitudinal vein setose to discal cross-vein only; large species with clear wings and large antennae, 3rd joint being about five times as long as the 2nd in male . . **succincta,** Mg.

Of the above there are only two species with which I am familiar; *nigrans*, Mg., is a very small black-looking fly, occurring on sandhills and probably

common in such places. Stein in error called it *migrans*. It belongs to a group of closely allied species, all small, which seem to have been much confused, and the correct naming is accordingly rendered very difficult; Dr. Villeneuve tells me, however, that our species is identical with Meigen's type of *nigrans*. We may, however, easily have other species occurring here, and in particular *carbonaria*, Panz., in which the 1st longitudinal is also setose, and the setae on the second end at the discal cross-vein otherwise closely resembling *nigrans*. *Costata*, Fall., is another nearly allied species, but definitely larger and less dark; so far I know of only one specimen, a female in Mr. J. E. Collin's collection, taken by Rev. E. N. Bloomfield at Guestling, Hastings, in 1890.

Lentis, Mg., is the other not uncommon species, and I have seen specimens from Logie in the north of Scotland to Devonshire; it belongs to a distinct group of larger insects to which our remaining two species also belong. Of these two species I have seen but odd specimens; one male that Dr. Wood had from Woolhope, which I identified as *succincta*, Mg., Dr. Villeneuve, who saw the specimen, agreeing; and another male from Whitchurch, which Dr. Villeneuve named doubtfully as *latifrons*, Zett. (*non* Sch.). More recently Mr. J. E. Collin sent me a pair taken near Oxford by Mr. J. Collins, the male from Wytham, Berks, 20.vi.1914, and the female from Cothill, Berks, 30.v.1914, which appear to be also *latifrons*. The male had the frons wider than in the female, a very unusual sexual dimorphism; but in spite of this fact I felt sure that they both belonged to the one species. Further, there is a specimen in the British Museum from Tarrington (Yerbury), which also belongs here, I think. The species seem distinct enough so far as my small material allows me to judge, but I cannot help wondering if a good series might lead to the linking up of two or perhaps all three of them. They need confirmation.

54. Ptychoneura, B. & B.

1. Facialia ciliated upon at least the lower two-thirds of their length; genae with a few hairs only on the upper part; tarsi more or less rufous **rufitarsis**, Mg.
2. Facialia ciliated only a little way up, about one-quarter; genae, on the contrary, with bristly hairs almost down to the mediana; tarsi quite black . . . . . **cylindrica**, Fall.

I have placed this genus here in the order in which it appears in the *Katalog der Pal. Dipteren*, although actually it is a Sarcophagine and nearly allied to the species of the *Miltogramma* group. It has the interfacialia deeply hollowed out with the antennae sunk into it; arista thickened for three-quarters of length: abdominal macrochaetae very short and inconspicuous; cubital appendage to bending of 4th vein. It consists of two very small species, which may be common but overlooked. There is a series of *rufitarsis*, Mg., in the British Museum from Felden, Herts (A. Piffard), and I have taken or seen specimens from the New Forest; Stoke Woods, Hereford (J. H. Wood); Cambridge (F. Jenkinson); Crowborough (F. Jenkinson); Tunbridge Wells (Col. Nurse), etc. *Cylindrica*, Fall., not previously recorded as British, I have taken or seen from Aviemore; Herefordshire (Dr. J. H. Wood); Cambridge (F. Jenkinson); Tunbridge Wells (Col. Nurse); Tubney near Oxford (J. Collins), etc.; Newmarket (J. E. Collin); Bridgend (Col. Yerbury); Abergavenny (Chapman), and Monifieth (A. E. J. Carter).

55. **Rhacodineura**, Rond.

One well-known species, **antiqua,** Mg., usually recognised at once by the failure of the apical portion of the 4th longitudinal vein, though individuals are supposed to occur with this vein complete. *Phytomyptera* and *Actia frontalis*, Macq., also have the same part of the vein missing, but are much smaller species with shining black appearance, whereas *antiqua* is a larger insect, almost the size of *Musca domestica*, L. It has long antennae, 3rd joint five times the length of 2nd; 3rd black, 2nd red; facial setae ascending about halfway up the facialia; frons very wide; abdomen with dense even yellowish tomentum; legs yellow excepting the tarsi. It is common and widely distributed.

56. **Phytomyptera**, Rond.

One species only, **nitidiventris,** Rond. (**nigrina,** Stein), one of our smallest Tachinids. A shining black species again easily recognised by the missing apical portion of the 4th longitudinal vein, together with the failure of the hinder cross-vein also. I have not seen many specimens, but they were from widely separated localities, and again I suspect that it is a species which has been overlooked on account of its small size. Amongst other localities are the New Forest; Stoke Wood, etc., in Herefordshire; Guestling, Hastings (Rev. E. N. Bloomfield); Barmouth (R. C. Bradley); Tunbridge Wells (Col. C. G. Nurse); Studland (Col. Yerbury), etc.

57. **Hebia**, R.-D.

One rare and little-known species, **flavipes,** R.-D. (= **Erythrocera pauciseta,** B. & B.). Dr. J. H. Wood took this in several localities in Herefordshire; I found it at Upper Arley in Worcestershire, and have besides seen odd specimens from Barton Mills, Suffolk (J. E. Collin); Ipswich District (Claude Morley); Lyndhurst (Col. Yerbury), and Lee Abbey, N. Devon (Dr. Hunter). In *E.M.M.*, 1905, p. 203, this species was recorded by me under the name *Rhacodineura pallipes*, Fall. *Pallipes* is usually regarded as being synonymous with *antiqua*, Mg., and it is probably best to continue to do so, and as Dr. Villeneuve tells me that the present species is certainly *Hebia flavipes*, R.-D., it is a better name to employ. There is very remarkable sexual dimorphism exhibited in the antennae, the male having the long 3rd joint nearly all black with only the two short basal joints yellow, whilst the female has the entire antennae of a clear bright yellow which gives a brilliant appearance to the head. (According to Lundbeck the antennae in the female are sometimes dark, but all I have seen are as described.) In general the male is very like a *Rhacodineura* with complete 4th vein; the facial setae ascend higher, nearly to the arista; there are some hairs on the upper part of the genae, and there are dark margins to the abdominal segments.

58. **Bucentes**, Latr.

1. First abdominal segment with a pair of hind-marginal macrochaetae; the largest species; the lateralia being narrow and the underside of the head being curved upwards in front, the vibrissae are brought into a line a little above the level of the lower eye margin. Usually there is little or no yellow colouring on the abdomen even of the male. Four D.C. . . . . **geniculata,** Deg.
2. First abdominal segment with no hind-marginal macrochaetae as a rule; smaller species; lateralia being wide, although the underside of the

head is curved upwards in front, the vibrissae are not above the level of the lower eye margin. The yellowest species of the three; the abdomen in the male is usually broadly yellow at the sides, and even in the female there is generally some distinct yellow at the sides of the base of the abdomen. Four D.C. as a rule, but the fourth frequently and the third sometimes slight and hair-like . . . . . **cristata,** F. (**oculata,** Pand.).

3. First abdominal segment with no hind-marginal macrochaetae; the smallest species; the lateralia are so wide and the underside of the head is curved up so little in front that the vibrissae remain on a line well below the level of the lower eye margin; the darkest species, with no yellow colouring as a rule even in the male. Three D.C. **maculata,** Staeg.

I have adopted Lundbeck's names in this genus, and am informed that they are in accordance with the types.

There is a fourth species with hind-marginal macrochaetae on the 1st segment as in *geniculata*, Deg., but with as much yellow on the sides of the abdomen as in *cristata* and with three D.C. only, namely **flavifrons,** Staeg. One Cambridge specimen taken by Mr. F. Jenkinson answered to this description, but there is a great deal of variation in this genus, and unless or until one can get a fairly consistent series it must remain a doubtful species.

The females are far more difficult to identify than the males, especially as the character of the width of the lateralia and consequent position of the vibrissae is almost lost in this sex; but size and colour will help in combination with chaetotaxical characters:—*maculata* very small and dark; *cristata* larger with some yellow; and *geniculata* the largest and again dark. All three species are common and generally distributed; *geniculata*, Deg., the commonest, probably occurring everywhere, including Scotland and Ireland, from both of which I have specimens. They are immediately and readily identified by the long elbowed proboscis, which is possessed by no other British Tachinid.

59. Blepharomyia, B. & B.

Until quite recently there was considered to be but one species in this genus, which was quoted in the Katalog (8) as *pagana*, Mg., with *amplicornis*, Zett., and *incerta*, Meade, as synonyms. Stein, however, in his posthumous work (24) showed that there were two distinct species, of which the one which he called *pagana* has a narrow frons in the male, barely one-third of eye width with no fronto-orbital setae, and the other, *amplicornis*, Zett., has a frons at least two-thirds of eye width and possesses fronto-orbitals in the male. Of these two species *pagana* does not appear to be British.

The re-examination of available material necessitated by Stein's results has led me to discover that we have still a third species of the genus which I am venturing to describe, in compliment to my friend Mr. J. E. Collin, under the name of

Blepharomyia collini, sp. nov.

♂. Frons fully of eye width, frontalia dull black, frontal orbits dark and shining in upper part, and equal in width to the frontalia; profrons rounded; genae a little narrower than frontorbita; lateralia about equal to half the eye height; face somewhat shortened, but vibrissaria below the level of the under edge of the eye. Head dark throughout with dull yellowish tomentum; palpi dark. One strong vertical bristle each side; a pair of small post-verticals and a pair of rather small ocellars; one praevertical bristle curving outwards over the eye on each side; two strong fronto-orbitals and a number of more or less bristle-

like hairs in series with them. There are strong bristles and hairs on the genae which in general continue the frontal and fronto-orbital series and extend to the mediana. Only three setae close to the vibrissae on the facialia. Antennae black, 3rd joint large and wide, about twice as long as wide and between three and four times as long as the 2nd. Arista thickened nearly to the middle, with the 2nd joint slightly lengthened. Thorax and scutellum dark with thin tomentum showing but indistinct markings; no praesutural intra-alar; acrostichal series with three pairs post-sutural and two pairs praesutural; D.C. series with three post and three praesutural pairs. Scutellum with crossed apicals and two strong long laterals on each side and one pair of discals. Alulae yellowish. Abdomen dark, 1st visible segment with very slight tomentum, other three segments with bands of yellowish tomentum on fore half of each. Full series of marginal setae on each segment and one pair of discals on 2nd and 3rd visible segments and a full series on the 4th. Legs quite black and very setose. The female is very similar, but frons a little wider still, the frontalia rather wider than the frontorbita; antennae with 3rd joint not enlarged and only a little over twice as long as the 2nd.

This new species may easily be confused with *amplicornis*; it, however, has a still wider frons, this, even in the male, being fully equal to the width of a single eye, and in the female it is still wider; whilst in *amplicornis* it is in the female distinctly less than eye width, and in the male, as above stated, only about two-thirds. Further, the frontorbita in the male of *collini* are as wide as the frontalia, and in *amplicornis* but little more than half as wide; and in the female of *collini* the orbits are as wide as in the male, but not quite so wide as the frontalia, which is larger in this sex. The abdominal segments in *amplicornis* have two central marginals on the 1st visible segment, two discals and two marginals on the 2nd, two discals and a full series of marginals on the 3rd, and there are the usual side bristles; in *collini* there is a more or less complete row of marginals on each of the segments including the 1st. *Collini* too seems to have the genae more setose, but I have only seen two males and one female, and they vary somewhat in this respect. In all other respects *collini* resembles *amplicornis*, even the genitalia which have not been fully examined being apparently the same. The species is described from three Scotch specimens from Mr. J. E. Collin's collection; two males, one of which I have designated the type, from Callander, 3.vi.1916, taken by A. E. J. Carter, and a female from Glenmore, 5.vi.13; and I have since seen one male from the Cambridge Museum taken at Nethy Bridge vi.07 (Dr. Sharp ?).

Amplicornis, Zett., is perhaps rather commoner; perhaps a more southern insect. I have examined a series of five males and six females from various localities in Nottinghamshire kindly sent to me by Prof. J. W. Carr; there is one female in my own collection from the New Forest, and I have seen a co-type of Meade's *incerta* in Mr. J. E. Collin's collection. This latter, taken in the Ipswich District, 26.iv.97, by Mr. Claude Morley, is, I have no doubt, *amplicornis* as described by Stein (24) and Lundbeck (28), and agrees exactly with the Nottinghamshire series. Other specimens that I have seen earlier and not re-examined might of course prove to be *collini*.

Some of the Nottinghamshire specimens had been bred from *Hybernia marginaria*, Bkh.

60. Neaera, R.-D.

Albicollis, Mg. I found two males of this very distinct little species at Aston Rowant, Oxon, on July 30, 1927. Its arista, thickened nearly to the tip with the two basal joints lengthened so that the 3rd is only about twice the

length of the 2nd and the 2nd twice that of the 1st, will enable it to be distinguished at once from the typical species of the *Actia* group which in general it resembles; its enlarged 3rd antennal joint is also characteristic. The eyes are slightly hairy, but very sparsely and indistinctly so; there are only two or three long setae on the 1st longitudinal wing-vein; the 1st posterior cell is closed; there is a slight stump of a cubital appendage at the bending of the cross-vein; wings milky white; antennae, palpi, legs all dark; abdomen black with white tomentum on fore margins; discal and marginal setae present; four D.C.; facial setae ascend the facialia nearly to the middle. It seems a very little-known species, Stein (24) only refers to it casually and Lundbeck (28) not at all, and Baer (30) only includes it in his tables and has no more to say about it. On looking through Mr. J. E. Collin's collection I found a female of the same species taken by Mr. J. Collins at the same locality in 1920.

61. **Digonochaeta**, Rond.

1. Palpi more or less pale; females generally with some fulvous colour on the antennae; head and thorax with dense whitish tomentum which almost gives them a whitewashed appearance; only fine dark lines show through the white. Eyes with scarcely if any trace of hairs. **spinipennis,** Mg.
2. Palpi black; antennae quite black; the tomentum on thorax, etc., is brownish grey rather than white and less dense, and there are three wide dark lines showing distinctly on the thorax; there are unmistakable hairs on the eyes . . . . . **setipennis,** Mg.

These two may be but forms of one species, and Villeneuve and others are inclined to treat them as such; but I still fancy that the distinctions which Meigen observed hold good. *Setipennis*, besides its darker colouring, has also, I think, wider lateralia, perhaps through the eyes being smaller, and narrower antennae. *Spinipennis* is a common species, and I have many records but none of them Scotch; on the other hand, the few specimens I have identified as *setipennis* have all been Scotch, so that perhaps it is a northern insect. The localities are Nethy Bridge (C. G. Lamb), Logie (F. Jenkinson), and Aviemore, where I took two females myself. In the British Museum too is a series of seven males and four females named as *setipennis*, and they are all from Scotland, from Brodie and Nairn (Col. Yerbury). The species of this genus can be readily recognised, by the thickened arista, with the 1st and 2nd joints long and each about two-thirds the length of the 3rd; the large antennae, setose genae, setose 1st and 3rd wing-veins, and nearly bare eyes. They resemble *Actia* in size and form.

62. **Stenoparia**, Stein.

One species only, **monstrosicornis,** Stein, only recently described in Stein's new monograph (24), although it has been known to me since 1916. Villeneuve had also met with it and had provisionally named it *ornatipennis*, which name, however, was never published, so that Stein's has to be adopted. It is a distinct species of typical Thryptoceratid appearance, but its big male antennae, elongated 2nd aristal joint, narrow genae with a single row of short setae, three D.C. and yellow legs will enable it to be readily recognised. The setae on the 3rd longitudinal vein extend to the smaller cross-vein. There is a specimen, a female, in the Cambridge Museum taken by F. Jenkinson in his garden at Cambridge on 26.v.05, and Mr. A. H. Hamm took one male at Shotover on 6.v.16.

63. **Actia**, R.-D. (See Pl. IX, fig. 4.)

1. Wings with the 1st, 3rd, and 5th longitudinal veins more or less setose . 3.
   Wings with the 3rd vein only setose . . . . . 5.
   Wings with the 3rd and apical portion of the 1st setose . . . . . 2.
2. Legs dark; 1st and 2nd aristal joints short; antennae dark and 3rd joint not unusually widened; frontalia dark and not much wider than orbits. **antennalis,** Rond.
   Legs all yellow excepting tarsi, which are dark; 1st and 2nd aristal joints elongated, 2nd being one-third the length of the 3rd, 1st about half length of 2nd; antennae with 1st and 2nd joints clear yellow and 3rd yellowish, the 3rd being greatly enlarged and very wide; frontalia bright fulvous and much widened, more than twice the width of one orbit. **verralli,** n. sp.
3. Wings with the apical portion of the 4th longitudinal vein failing; palpi dark . . . . . **frontalis,** Macq. (**lamia,** Mg. Stein).
   Wings with the 4th longitudinal vein complete; legs dark; palpi yellow . 4.
4. Wings with the 1st longitudinal vein bare on the basal two-thirds and setose on the apical portion alone . . **nudibasis,** Stein (**pilipennis,** Villen.).
   Wings with the 1st longitudinal vein with both the central and apical portions setose above (the actual basal portion being bare in all), and the apical portion setose beneath also; the setae long, distant and equal. **crassicornis,** Mg.
   Wings with the 1st longitudinal vein with central and apical portion setose above only; setae irregular, long ones interspersed with short ones. **pilipennis,** Fall. (**reducta,** Villen.).
5. Third joint of antennae deeply cleft nearly to the base, so as to appear from the side as if the joint had been duplicated . . **fissicornis,** Strobl, ♂.
   Antennae normal . . . . . 6.
6. Femora dark; four D.C.; palpi yellow; tibiae yellow; 3rd longitudinal vein setose nearly to the tip; 2nd joint of fore tarsi lengthened and dilated. **fissicornis,** Strobl, ♀.
   Femora more or less yellow . . . . . 7.
7. Abdomen entirely yellow, or at most showing a narrow dark central line; legs almost all yellow excepting the tarsi; four D.C.; setae on the 3rd longitudinal vein extending past the discal cross-vein; palpi yellow. **bicolor,** Macq.
   Abdomen yellow at the sides only; legs yellowish but somewhat darkened; three D.C.; setae on the 3rd longitudinal vein cease at the discal cross-vein; palpi yellow . . . . . **anomala,** Zett.
   Abdomen all black, rather densely covered with ashy-grey tomentum; legs with yellow tibiae and the femora also yellow but with dark patches and streaks; four D.C.; the setae on the 3rd longitudinal cease before the discal cross-vein; 1st and 2nd joints of arista lengthened, the 1st nearly as long as the 2nd, which is three or four times as long as wide; 3rd joint of antenna large, dark, about twice as long as wide, and about four times as long as the yellow 2nd . . . . . **nigrohalterata,** Villen.

This is a genus of small flies which are not yet well understood anywhere. There are probably a number of fresh species yet to be identified, and several of those already known on the Continent may well prove to be British. They are all small and characterised by the males possessing the same wide frons and fronto-orbital setae as the females; by the 1st posterior wing-cell ending practically at the wing-tip; also by the short stumpy legs and extremely reduced tarsal claws; bare eyes and genae; no discal abdominal macrochaetae; bending of the 4th longitudinal rather flattened out and curved gently up to hind margin.

Crassicornis, Mg., and *pilipennis*, Fall. (= *reducta*, Villen.), are the commonest and best-known species. There is a third species of the group, *nudibasis*, Stein, described in Stein's posthumous work (24), which I have not yet detected in this country,* but which I have included in my table because these three species are so closely allied that it is necessary to watch them very carefully, and it may yet be found. Villeneuve had called my attention to this third species years before Stein described it, but in his opinion Fallen's *pilipennis* was the one with the basal portion of the 1st longitudinal vein bare, *i.e.*, *nudibasis*, Stein, and the species Stein assigned to *pilipennis* was in Villeneuve's opinion the new one and was named by him, *reducta*. I had previously identified a number of specimens in various collections in accordance with Villeneuve's views, and the names must now be altered.

Frontalis, Macq. is, I believe, also common, but I have records only from the Wyre Forest district, where I have taken a series; Logie (F. Jenkinson); Tarrington, and Shobdon Marsh, Hereford (Dr. J. H. Wood). *Bicolor*, Mg., seems rare, and I know of very few specimens: Cheshire (1, H. S. Leigh); one male and three females bred from *Lasiocampa quercus*, L., taken at, I believe, Newport, Salop (A. Roebuck); Invershin, Sutherlandshire (1, Col. Yerbury); West Mersea, Essex (1 in Brit. Mus.); Kirtling, Cambridgeshire (1, J. E. Collin); Rannoch and Aberfoyle (A. E. J. Carter) single specimens. *Anomala*, Zett., was discovered by me at Wormsley in Bucks, where I took a short series on one occasion. It must have been abundant there, but that is all that is known of it as British at present.† *Antennalis*, Rond., was also taken on the same occasion at Wormsley, but only two females, and the only other British one known yet is another female taken by F. Jenkinson in his garden at Cambridge. *Fissicornis*, Strobl, is a very remarkable species with its deeply cleft 3rd antennal joint, a character not known, I believe, in any other European fly, and the male as a consequence cannot be mistaken for any other species. The female, however, has normal antennae, but can be recognised by the characters quoted in the table. The species has only recently been described, and it is singular that it should have been overlooked for so long as already it has been recorded from several European countries. Mr. G. T. Lyle bred a small series from larvae of *Ourapteryx sambucaria*, L., found in the New Forest.

Nigrohalterata, Villen., was not known as British until quite recently Mr. J. E. Collin sent me two specimens, a male and a female, taken at Wood Ditton Wood, the male on 23.v.27, the female on 10.v.20. The specimen of *verralli* described below being similar in many respects, all three flies were sent to Dr. Villeneuve to be compared with his type, and in accordance he reported that the Wood Ditton specimens agreed with his *nigrohalterata*, and that the other was not known to him. *Nigrohalterata* appears to be a small species, it is ashy-grey in general effect and should be readily identified by the characters quoted in the table. The other species I am describing as new under the name of

Actia verralli, sp. nov.

Belonging to the group with the femora more or less yellow and with the 5th longitudinal wing-vein bare, it is distinguished at once by the possession of a few setae on the apical portion of the 1st longitudinal wing-vein, and by the

* I have since come across one female in Mr. J. E. Collin's collection, taken at Weybridge, 10.vii.11.

† Mr. J. E. Collin has a specimen taken by Col. Yerbury at Crymlyn Bog.

lengthened first two aristal joints, the 1st being about twice as long as wide, the 2nd about twice as long as the 1st, and the 3rd perhaps three times the length of the 2nd; also by the legs, excepting the tarsi, being entirely yellow.

♂. Frons very wide, one and two-thirds times as wide as one eye as seen at the vertex; frontalia also very wide, fully two and a half times as wide as a single orbit, and widening still more in front; it is orange-red in colour and waxy in appearance; orbits, genae and whole face covered with yellowish tomentum; both pairs of vertical setae strongly developed; the ocellary setae strong and curved outwards rather than forwards; a pair of short post-verticals; two pairs of upper recurved frontals or praeverticals; frontals continued to end of 2nd antennal joint; usual fronto-orbitals, etc. Antennae very large, 3rd joint twice as long as wide and four or five times as long as the 2nd, and reaching fully to bottom of the face; 1st and 2nd joints bright yellow, and 3rd also yellowish. Arista as described above. Genae narrow; lateralia about one-quarter of eye height; palpi clear yellow. Thorax covered with light brownish tomentum, showing no stripes, but all hairs and setae arising from black spots; acrostichals and dorso-centrals in full series, four pairs behind and three pairs in front of suture in each. Scutellum yellowish, with small apical setae, and three other pairs of strong marginals. Abdomen black with no trace of rufous at sides, covered with yellowish-brown tomentum, densely in a narrow fore margin to each segment and thinly for the rest. Legs of a clear yellow throughout excepting for the black tarsi, there is no trace of darkening on the femora and the coxae and trochanters are equally yellow. Wings with a row of strong setae (8 in the type) on the 3rd longitudinal vein, not reaching quite to the discal cross-vein, and a short series of similar setae (4 in the type) on the apical portion of the 1st longitudinal. Postical cross-vein about midway between the discal and the bending of the 4th vein. Halteres clear yellow.

A single specimen was taken at the Mound, Sutherlandshire, on 26.vii.14, by Mr. J. E. Collin, and is now in his collection. I have dedicated the species to my late friend Mr. G. H. Verrall, who did so much for British dipterology.

Siphonoides, Strobl, seems to be a closely allied species, but appears to differ in a number of points; it is described as having short basal aristal joints; three D.C.; and as being darkened on the femora, antennae, palpi, etc., and apparently has no setae on the 1st longitudinal vein. Those other species like *tibialis*, R.-D., which have setae on the 1st longitudinal, all appear to have the legs dark at least on the femora.

64. Thryptocera, B. & B.

One species only, **versicolor,** Fall. This genus is doubtfully distinct from *Actia*, being separated from that genus only by the possession of discal abdominal macrochaetae. The species closely resemble those of the previous genus. I possess one female from Colchester (W. H. Harwood), but otherwise know of no other certain British specimen. *Versicolor* has entirely yellow legs, palpi, frontalia and basal joints of antennae, and the 3rd longitudinal vein is setose to beyond the discal cross-vein.

65. Helocera, R.-D.

Delecta, Mg., the only species; not previously known as British. Three specimens were taken by the late F. Jenkinson at Cambridge in his garden. It is a species very similar to those of the genus *Actia*, but with a few setae at the base of the 3rd longitudinal vein only. It has rufous sides to the abdomen at the base, and no discal setae; no palpi, these being apparently entirely wanting; in the male the fronto-orbital setae are not fully developed, being

sometimes one, sometimes irregular small ones; legs longer than is usual in this group of species.

66. Admontia, B. & B.

The species of this genus are not really well known; apparently they are extremely variable in characters usually regarded as stable, such as the shape of the head, especially its length, and the width of the lateralia and also the width of the genae; also the number, etc., of the setae both on the genae and on the facialia varies, so that without much material it will be difficult to arrive at any certain conclusion. Stein seems to have had a fair series, and decided that there was only one species, which he called **podomyia,** B. & B., saying that Meigen's type of *amica* is missing and cannot be identified. Lundbeck also mentions one species only, but calls it *amica*, Mg. I am following Stein for the present. I have specimens from Barmouth and Aviemore, and have seen others from various localities in Herefordshire (Dr. J. H. Wood), and one male from Bawtry, Notts (Prof. Carr); unfortunately most of these happened to be more or less imperfect. A specimen taken at Whitchurch (Salop ?) in Dr. Wood's collection may be *amica*, Mg., if that is really a distinct species; *amica* is supposed to have a much longer head, with very wide lateralia equal to as much as two-thirds of the eye height; the antennae also are longer. These are larger insects than those of the preceding genera, of more ordinary Tachinid appearance, of the *Phryxe vulgaris*, Fall., type, size, and colour. They have ascending facial setae, reaching to above the middle; bristly hairs on the genae; antennae long and thin, 3rd joint six times as long as 2nd in the males; arista with 2nd joint about three times as long as wide; black legs, antennae and palpi; narrow bands of whitish tomentum on fore edge of segments.

67. Trichoparia, B. & B.

1. Thorax with two broad black stripes, which unite behind the suture and there occupy the whole disc; there is a transverse line of conspicuous silvery tomentum just before the scutellum; the humeri, the sides of the thorax and a narrow central stripe in front are also conspicuously silvery; the rest of the thorax is shining black. On the abdomen also there are sharply contrasted narrow silvery bands of tomentum on the fore margins, and broad shining black hind margins . . . **blanda,** Fall.
2. Thorax with four black lines, the two central ones narrow and the side ones broad, leaving much tomentum between them on the disc; the tomentum not silvery and conspicuous as in *blanda* in any part. On the abdomen also the tomentum extends over the greater part of the segments, is brown in tone, and forms no clearly defined bands. **seria,** Mg.

This genus is very closely allied with *Admontia*, with which indeed it would be better united. The only distinctive character seems to be the absence of apical scutellars in *Trichoparia*, but they are not strongly developed in *Admontia*, and in other respects the species of the two genera are so much alike as to be distinguishable only with difficulty. The restriction of the silvery tomentum in *blanda*, and the sharp contrast between it and the extended black shiny parts of thorax and abdomen, will probably enable it to be separated from either *seria* or *podomyia*, in both of which the tomentum is spread and ill-defined. In *seria* the abdomen is almost all tomentose and brownish in colour; in *podomyia* the tomentum is whiter and more restricted to the fore margins of the segments, in this respect being more like *blanda*, but unlike that species in the possession

of four dark lines on the thorax as in *seria*. *Seria* has yellow alulae and wing-bases, whilst *podomyia* has them clear.

The species are all rare. Dr. J. H. Wood seems to have found *seria* occurring regularly in Stoke Wood, Herefordshire, otherwise I have seen only odd ones from Sutton Coldfield (R. C. Bradley), Bishop Auckland (Wingate), and Aspley Wood, Notts (Prof. J. W. Carr). *Blanda* I did not know until recently I detected a female amongst some captures made by F. Jenkinson and sent to me by Mr. Hugh Scott for identification. Unfortunately its label was missing, but Mr. Scott has since examined it carefully and is of the opinion that it is undoubtedly one of Jenkinson's captures, and certainly British, but the actual locality must now remain unascertainable, though Cambridge is most probable.

68. **Craspedothrix**, B. & B.

Another genus of small flies closely allied to and resembling those of the genus *Actia*, from which they are distinguished by the bare wing-veins, there being only one longish bristle just at the base of the 3rd vein. The species closely resemble in most respects those Actias with all black antennae, legs and abdomen. We have, I believe, but one species, **zonella,** Zett.; my specimens seem to agree with Stein's and Lundbeck's descriptions of their *zonella*, and both authors had examined Zetterstedt's type, which they say is identical, so that it would seem that this must be the correct name for our insect. There seems, however, to have been much confusion regarding the species, of which Villeneuve thought there might be four. *Zonella* seems to be fairly common, and I have seen specimens from a number of localities.

69. **Erythrocera**, R.-D. (= **Discochaeta**, B. & B.).*

Another genus closely allied to *Actia*, our single species being very much like *A. crassicornis*, Mg., etc., but having only three or four strong setae at the base of the 3rd wing-vein and the veins otherwise bare; there are discal macrochaetae on the 3rd visible segment; the antennae are partly yellow; the basal joints and the inner side of the 3rd one, also the scutellum are largely yellowish, and the alulae and wing-bases are also somewhat yellow; there are only very slight pruinose bands on the abdomen, which is almost all shining. The single British species **scutellaris,** R.-D. (**hyponomeutae,** Rond.), seems to be very rare as I only possess one female specimen from Bexley, Kent (H. W. Andrews), and have seen no other.

70. **Arrhinomyia**, B. & B.

1. Species entirely shining black, the only tomentum being a little on the humeri; facial setae not reaching the middle of the facialia, barely extending more than halfway to the lowest frontal setae . . **tragica,** Mg.
2. Species with some tomentum on the fore margins of the abdominal segments, on the thorax and even on the dark frontorbita, but the insect remains shining-looking; facial setae reach well beyond the middle . . . . . **cloacellae,** Kramer.

Two small species of undistinguished appearance, which, however, should be recognised by the characters given, the shining frons, and ascending facial setae, and by the fronto-orbital setae of the male. They are entirely black, legs, palpi, antennae, etc. The 1st posterior wing-cell ends at the wing-tip; the 4th longitudinal vein is bent in a curve. I have not taken either species

* Dr. Villeneuve is my authority for the names of this species.

myself, but Mr. J. E. Collin has a male of *cloacellae* from the New Forest, taken 24.vi.21, by A. E. Tonge; and of *tragica*, Mg., he has a male from Blairgowrie and a female from Aberfoyle, both taken by Mr. A. E. J. Carter, a female from Rannoch, and another from Herefordshire bred by Dr. J. H. Wood from "*H. servillana*," and I have also seen a single female taken by Mr. F. Jenkinson, 7.ix.05, at Newtonmore, and now in the Cambridge Museum.

71. APATELIA, Stein.

One species, **innoxia,** Mg. (= **Hypostena procera,** Sch. et auct. nec Mg.). Of this rare species I knew practically nothing until just recently I detected a male specimen, taken by Dr. D. Sharp in the New Forest in 1905, amongst a lot of specimens sent to me from the Cambridge Museum for identification. As Stein (24) states that the chief generic character is the broad frons in both sexes (in the male wider than an eye) with one fronto-orbital each side in the male, and the usual two in the female, and as it happens that in our specimen, a male, the orbitals failed entirely, I sent it on to Dr. Villeneuve for comparison, though feeling certain of the correct identification, and he agrees. It will be interesting to see when more specimens are known if it was pure chance that the first certainly known British specimen of this species should lack these setae, or if it should prove to be a characteristic of the British race. As already mentioned the chaetotaxy in this family is always liable to variation even in such characteristic items as the fronto-orbitals, which one occasionally finds differing on the two sides of a head. In all other respects the specimen agrees with descriptions, and can be known by the long rather tubular abdomen, which is distinctive; by the very long plump antennae, which arise high on the head and extend right to the epistomal edge, with the 3rd joint about eight times as long as the short 2nd. It is small black and shiny, with narrow silvery margins to the segments, and conspicuously silvery humeri as in the next genus; three D.C.; three strong pairs of marginal scutellars, but no apicals; the abdomen with discal and marginal setae. The eyes are large and high; the lateralia small; the succiput very short.

It has been generally known until recently as *Hypostena procera*, which name is to be found in earlier lists, but I had not hitherto seen a British specimen of which I was certain.

72. DEGEERIA, Mg.

1. Frons at vertex in male as wide as one eye; male with fronto-orbital setae; female with the fore edges of each ventral segment produced and bearing strong short bristles, the result being to give a saw-like appearance to the underside . . . . . **Microvibrissina muscaria,** Fall. q.v.
   Frons at vertex in male narrow, less than half eye width; female with no saw-like development of the underside . . . . . 2.
2. Male possessing a conspicuous tuft of hairs on the underside of the abdomen about the genitalia. Abdomen with a little whitish tomentum on the fore part of each segment at the sides, otherwise without tomentum and therefore dark and shining; small species not exceeding 5 mm. in length . . . . . **luctuosa,** Mg.
   Male with no such tuft of hairs. Abdomen all excepting the 1st segment nearly covered with tomentum; larger species, 6 mm. or more in length . . . . . **collaris,** Fall.

The typical species of this genus are distinguished by possessing rather conspicuous spots of whitish tomentum in front of the thoracic suture at each

side, and with their slender form and long legs are easily recognised. *Collaris*, Fall., is common and sometimes occurs in numbers. Occasionally large specimens are found, and I possess one male from Rannoch which is quite 9 mm. long. These specimens seem to differ from typical ones in no respect save size.

Luctuosa, Mg., seems to be rare. I have it from the Doward, Herefordshire (Dr. J. H. Wood), and Studland Heath, Dorset, and have seen specimens taken by Dr. Wood in other Herefordshire localities; from the New Forest (Miss M. A. Sharp); Felden, Herts (A. Piffard); near Oxford (J. Collins and A. H. Hamm); and Porthcawl (Col. Yerbury).

Muscaria is not a true *Degeeria*. I have placed it here in conformity with the Katalog, but have dealt with it under the newer generic name of *Microvibrissina*.

73. **Pelatachina**, Meade. (See Pl. IX, fig. 6.)

One species only, **tibialis**, Fall., a fairly distinct insect with prominent profrons, long legs and yellow tibiae, largish size—it is about 8 mm. to 9 mm. long—and whitish dusted abdomen. The head is characteristic (see Pl. IX, fig. 6); discal setae on abdomen; three D.C.; no apical scutellars, three strong ones each side; no praesutural intra-alar. It is not uncommon and I have records from a number of localities, widely scattered and including Nairn (Col. Yerbury).

74. **Loewia**, Egger. (See Pl. X, fig. 9.)

1. Genae bare . . . . . 2.
   Genae armed with setae . . . . . 3.
2. Large stout species, 8 mm. or more long; with only very short or no stalk to 1st posterior cell; very narrow frons in male; eyes hairy in male and female . . . . . **brevifrons**, Rond.
   Smaller species, about 5 mm. long; stalk of 1st posterior cell equal to about one-quarter of the length of the apical cross-vein; male frons wider, equal to about one-quarter of eye width; eyes bare in female, hairy in male, but not conspicuously so. (There may be an odd one or two inconspicuous hairs at the bottom of the genae) . . **phaeoptera**, Mg.
3. Large species, about size of *brevifrons*?; long stalk to 1st posterior cell?; eyes hairy in male and female?; genal setae very long . **setibarba**, Egger.
   Smaller species; eyes bare in female; genal setae short . . . . . 4.
4. Species about 5 mm. long; stalk of 1st posterior cell equal to about half the length of the apical cross-vein . . . . . **petiolata** (R.-D.), Pand.
   Species about 6 or 7 mm. long; stalk of 1st posterior cell about one-quarter the length of apical cross-vein . **foeda**, Mg. (= **intermedia**, Brauer).

I have included in the above table two species which are very doubtful Britishers, but have been included in some of our earlier lists, and seem to call for mention. Of these *brevifrons*, Rond., is a distinct enough species, with quite bare genae; the stalk of the 1st posterior cell very short, and even non-existent sometimes, as the cell is closed close to if not actually at the wing-margin; and very narrow frons. It is a larger species than either of the others known to me, measuring fully 8 mm. long, and is a robust, stout-looking insect. I do not think it occurs here. *Setibarba*, Egger, is rather a doubtful species, and I am by no means sure that it is not identical with one of the others; I have never seen a specimen. It is supposed to be a large species again, similar in size to *brevifrons*, but with very strongly setose genae. The other three species are all smaller and very closely allied, but I believe distinct. *Phaeoptera* and *foeda* require careful observation as they vary in

size and in the genal setae; doubtful specimens can, I think, be identified by the shape of the genae, which in *phaeoptera* taper down almost to a point, whilst in *foeda* they taper but little, remaining comparatively wide below. All the species are characterised by the rounded head, somewhat semicircular in profile, with very short face, the antennae being inserted below the middle of the eyes; they are black and shining with very little tomentum and very setose. *Phaeoptera* is fairly well known as a British species under the name of *Fortisia foeda*, but is not common. I have it from the New Forest and Tunbridge Wells (Col. C. G. Nurse), and have seen others from Herefordshire (Dr. Wood), etc. *Foeda* (*intermedia*) has only recently been discovered here, the first I saw being sent to me by Prof. Carr from Nottinghamshire, two females from Mapperley and one from Radcliffe-on-Trent, and a male from S. Leverton; I have since seen two females taken at Yarnton (J. Collins), and one in Mr. J. E. Collin's collection from Newmarket, 13.vii.83. *Petiolata* seems still rarer. I have a male from Woking (A. J. Chitty), a female from West Runton, Norfolk, and have also seen odd ones taken by Dr. J. H. Wood at Stoke Wood, Herefordshire, by Mr. F. Jenkinson at Six Mile Bottom, and by Mr. J. Collins at Tubney.

75. MACQUARTIA, R.-D. (See Pl. X, fig. 7.)

1. Legs more or less yellow . . . . . 2.
   Legs all dark . . . . . 3.
2. Legs in the males with only the tibiae yellow (in the females the femora and tibiae are entirely yellow) . . . . . **dispar,** Fall.
   Legs in the males with femora as well as tibiae yellow (females in this respect indistinguishable from those of *dispar*) . . . . **flavipes,** Mg.
3. Abdomen closely covered with yellowish grey tomentum. **(Cleonice) grisea,** Fall.
   Abdomen with little tomentum, so that it is more or less shiny . . . 4.
4. Thorax with four postsutural D.C. . . . . **nubilis,** Rond.
   Thorax with two or three postsutural D.C. . . . . 5.
5. Frontal setae ending in a bunch at the level of the antennae; a bluish-black species with black palpi, and very setose. **praefica,** Mg. **(spinicincta,** Meade).
   Frontal setae a little irregular at lower end, but running in almost a single line as in most TACHINIDAE; greenish-black species; palpi usually more or less yellow; less setose. . . . . 6.
6. Thoracic squamae narrow (as in *M. grisea*, Fall.), the result being that there is a wide gap between the edge of the squama and the scutellum; only two pairs postsutural acrostichals; apical ventral segment of the male enlarged and prominent. (Frons wider than in *tenebricosa*, being equal to width of 3rd antennal joint, the frontalia being distinct even at the narrowest point; thoracic lines forming three broad and distinct stripes; genae with very few hairs, and in upper part only). **buccalis,** R.-D.
   Thoracic squamae fully developed, the edge of the squama being close up to the scutellum; three pairs postsutural acrostichals; apical ventral segment of the male not enlarged and not prominent, nearly hidden. . 7.
7. No macrochaetae on the 1st abdominal segment; larger species; abdominal tomentum thick and well developed, extending over the 1st segment; male frons very narrow, reduced to a fine line with the frontalia disappearing at the narrowest part; colour greenish and tomentum brassy coloured . . . . . **chalconota,** Mg. Stein.
   Species with marginal macrochaetae on the 1st segment; smaller insects; tomentum less developed and bluish, sometimes almost none on the abdomen, and at least the 1st segment with very little and therefore dark and shining . . . . . 8.

8. Frons narrow, in male reduced to a fine line; frontalia disappearing at narrowest point; female has frons rather narrower than in the next species, and more parallel-sided; one pair discals only on each abdominal segment; shining black insects with tomentum little in evidence; female very like that of the next species, but reduced tomentum on abdomen and blacker colour may help to distinguish it . ? **tenebricosa,** Mg.

Frons wider in male, at the narrowest point usually equal to width of 3rd antennal joint, but somewhat variable, the frontalia being distinct even if very narrow at the narrowest part (there is a tendency for the head to shrivel in drying, which sometimes obscures this point); usually more than the one pair of discals; tomentum much more developed than in the last species, covering most of the abdomen, but it is thin, so that the abdomen is still shining but of a greener tone than in the last species; frons in female seems to widen more rapidly forwards than in the previous species and looks wider altogether . . . . ? **nitida,** Zett.

A well-known genus of largish species with long legs, characteristically shortened face, and consequently sloping underside. *Dispar* is a distinct and fairly common species, for which I have a number of localities, Upper Arley, Worcestershire, being, however, the most northerly. *Flavipes* is usually regarded as being only a variety of *dispar*, but all the specimens I have examined not only have the yellow femora, but seem to me to have a rather wider frons, equal to about one-fifth of the eye width, whereas the eyes nearly meet in *dispar*; in any case it is a well-marked variety and worthy of a distinctive name. It is rare, I have seen one male in the Verrall collection taken at Abbotts Wood, 24.vi.70, and another in the British Museum from Lyndhurst, and there is also a series of six males in the Museum taken by Col. Yerbury at Ivybridge. *Grisea* is another well-marked species for which I have records from a number of localities. *Nubilis*, Rond., has not been recorded as British before; it is readily distinguished by its four D.C., its short abdomen, narrow alulae, and very shining black appearance. It is also the smallest species in the genus. I have specimens from West Runton; Chalford, Glos., and Cusop Dingle, Hay; and have seen others from Felden, Herts (Piffard); Aldercar Wood, Newstead (Prof. Carr); Skelwith, Cumberland (H. Britten), and Tunbridge Wells (Col. Nurse). *Praefica*, again, is well characterised; it is much more setose than the other species, the increased number of setae on the abdomen resulting in a complete row of discals on the 3rd visible segment, and the bunch of setae terminating the frontal series is very distinctive. It, again, is a very shining black species. It seems common locally; I have a long series from Torquay and from Bagley Wood, Oxford, and have seen it from various other localities. I think it is probably Meade's *spinicincta*; and Dr. Villeneuve has compared it with Meigen's type of *praefica* (in Stein's work (24) misspelt *pacifica*), with which it agrees.

The remaining species form a group so closely allied that close observation is required for their separation. *Buccalis*, R.-D., is perhaps the most distinct, and can be separated at once from the others by the character of the squamae, when once that is appreciated. *Grisea*, Fall., and *nubilis*, Rond., share with it this peculiarity. In the majority of the TACHINIDAE this squama, or alula, is wide, so that it reaches out to the scutellum, and the margin of the squama and the edge of the scutellum adjoin or nearly adjoin for a considerable distance; in *buccalis* and the other species mentioned it is much narrower, and appears even longer than wide, and does not nearly approach the scutellum. *Buccalis* has only just been detected as a British species, Mr. J. E. Collin possessing a male and two females from Aviemore, taken 25.v.13 and 30.v.13, and in addition I

have a single male from Wyre Forest, 22.v.20. Apart from the characters already mentioned, it seems a "stumpier" species, less long-legged than is usual with the species of the genus, and small too, in this respect being like *tenebricosa*.

Dr. Villeneuve is definitely of opinion that the other species of this group are really varieties only of one common widely distributed species which he calls *tenebricosa*, Mg.,* and he tells me that he has intermediate specimens bridging every difference; the chaetotaxy is undoubtedly variable; also the amount of tomentum upon the abdomen; and in Dr. Villeneuve's opinion differences in the width of the frons are again due to similar variability. Nevertheless, I have thought it better to keep the forms apart, as so far as my experience goes they do fall into groups which may be varietal only or specific, but it will be necessary to make an exhaustive examination of the genitalia before one can decide with certainty. Müller (31) has already published the results of the examination of a few specimens, amongst which he appears to have found five different genital forms, so that it is obvious that we may yet have to modify our views considerably. *Chalconota*, Mg., has not yet been found in this country, which alone is a significant fact. It is true that the failure of macrochaetae on the 1st segment is a poor character, for they may fail occasionally in the other forms; but it is a constant character in *chalconota*, and is associated with large size, a very narrow frons, and, what I regard as being of special significance, the fact that the 1st segment is practically covered with the brassy tomentum. The other two forms do certainly run into one another more closely. Messrs. J. Collins and A. H. Hamm, however, bred long series of what I call *tenebricosa* from *Chrysomela varians* (Mr. Collins from Yanworth, Glos.; Mr. Hamm from Aldersmaston), and so far as I have seen them they are very constant, shining black, with only a little tomentum, rather a smaller species with, I think, somewhat shorter legs, and with a very narrow frons in the male; whilst the bulk of the specimens I have from other sources belong to the other form, called by me *nitida*, rather larger, greener in colour with more tomentum at least in the male, a slightly wider frons in which the frontalia is continuously visible, and, I think, rather longer abdomen and legs. It is true that a male Dr. Villeneuve sent me from Rambouillet and a German series in the Girschner collection have the narrow frons of the former, and the colour, tomentum and general appearance of the latter, but we do not seem to get such specimens here, so far as I have been able to judge at present, so that in this country the two forms seem to keep distinct, and it is well for them to have names. Unfortunately, it is almost impossible to select names other than arbitrarily at present, so that those I use are merely tentative. Both species or varieties are common and widely distributed.

The Rev. A. Thornley recently sent me a pair of flies taken *in cop.* at St. Ives, Cornwall, the male *grisea*, the female *dispar*; it was probably a case of abnormal pairing, still it does make one wonder if *grisea* and *dispar* could be but colour forms of one species.

76. MINELLA, R.-D.

1. Larger species, over 6 mm. long; frons in male wider than in the next species; frontalia nearly as wide as the frontorbita . . **chalybeata**, Mg.
2. Smaller species, barely 5 mm. long; frons in male narrower; frontalia reduced to a mere line . . . . . **nigrita**, Fall.

* If we accept the idea that all these are but forms of one species, the name should be *chalconota* rather than *tenebricosa* as it occurs first in Meigen; and our two insects might be var. *tenebricosa*, Mg., and var. *nitida*, Zett., respectively.

Very shiny black thickly setose species. The long succiput and projecting epistoma, short face and short antennae, and the dense cluster of lower frontal setae are characteristic; they have three D.C., crossed apical scutellars and discal abdominal macrochaetae, a few setae at the base of the 3rd vein, rounded bending of the 4th vein, etc. *Chalybeata* is common and well known, and I have specimens or records from many places in the southern half of England. *Nigrita* is but little known. I first had it from Herefordshire, where Dr. Wood took it in various localities, and have since seen specimens from Martham, Lyndhurst, Tunbridge Wells, and Eridge (all in the Verrall collection), Holne, Ivybridge and Avon Valley, Devon (all Col. Yerbury), and Teignmouth, so that it also appears to be widely distributed.

77. Hyalurgus, B. & B.

Lucidus, Mg., the only species. It seems rare and would not be readily overlooked, as it is a striking species with its almost entirely yellow abdomen and legs. There is a thin black central line on the abdomen; the scutellum and palpi are also clear yellow; the thorax grey; the head very like *Macquartia*, with shortened face and short antennae (3rd joint two and a half times the length of 2nd); frons in male about half eye width; three D.C.; apical scutellars crossed, and discals on the abdomen. Dr. Wood first found it in Herefordshire, at Woolhope, Ashperton Park, etc., and I have since taken it in Wyre Forest and at Rhayader, and have seen others from Logie (F. Jenkinson). Mr. Jenkinson informed me that it was fairly common on Umbelliferae in 1915.

78. Zophomyia, Macq.

Temula, Scop., a largish species, shiny black, with conspicuous yellow bases to the wings, easily recognisable and not readily overlooked. The head is Macquartian in type with small eyes and wide genae and lateralia; the male has well-developed fronto-orbital setae; the ocellars are markedly outward curved; strong abdominal setae, marginal and discal. It is very abundant in Switzerland, where I have often come across it, sometimes in numbers, and being familiar with its appearance and habits I have often looked out for it here, but without success. Verrall had a series of six specimens in his collection, but five were unlabelled and therefore of doubtful origin, and only one was ticketed, "Lyndhurst, 23/6/69"; further, I have seen in the Cambridge Museum collection two males and one female from the New Forest, 26.v—4.vii.1901, Dr. Sharp.

79. Demoticus, Macq.

One species, **plebejus,** Fall., which seems to be very rare. I have none, but the British Museum has specimens from Felden, Herts (A. Piffard), and from Crownhill Fort and Avon Valley, both in S. Devon (Col. Yerbury), all of which I have examined. It is the first of a group of largish species with cylindrical abdomen, usually with more or less rufous at the sides, and with longer faces than the preceding, but like them with projecting epistoma. It is like *Bithia spreta*, Mg., but has only two or three setae at the base of the 3rd vein. Arista has lengthened 2nd joint, and 3rd joint of antennae is large and wide.

80. Rhinotachina, B. & B.

Apparently rare. I took a single specimen, a male, at Barton Cliffs, Hants, on August 4, 1909, of the only species **modesta,** Mg., and nothing

else is known of it as a British insect. It is a close ally of *Demoticus* and *Bithia* and a similar-looking fly. The abdomen has no rufous sides and is evenly covered with ashy-grey tomentum; legs and palpi black; antennae small; 3rd joint twice the length of 2nd; 2nd joint of arista short; two or three setae on 3rd vein only.

81. **Bithia**, R.-D.

Again a single species only, **spreta,** Mg. (= **frontata,** Boh.). This is the one common species of the small group of genera to which it belongs, and is easily recognised when once known; it is above medium size, a greyish-fuscous insect of stocky appearance. I have seen it in abundance on more than one occasion, and have specimens and records from many localities including Kenmare and Stradbally, Ireland (H. W. Andrews), though, as it happens, none from Scotland. The setose 1st and 3rd wing-veins distinguish it at once from its allies; it has small antennae; the arista has only a short 2nd joint; palpi black; legs very slightly reddish on tibiae.

82. **Aphria**, R.-D.

Another single species, **longirostris,** Mg., a similar insect to the last three in size and appearance, but easily distinguished by its long and elbowed proboscis. I found it in some numbers about Studland Heath, Dorset, where I easily got a nice series, but have never met with it elsewhere, and have otherwise seen specimens only from the New Forest (G. H. Verrall, Dr. Sharp, Col. Yerbury, etc.), so that it would appear to be a very localised species. It has conspicuous rufous sides to the abdomen; no discal macrochaetae; arista has 2nd joint about twice as long as wide; antennae not large; only a few setae at base of 3rd wing-vein.

83. **Myiobia**, R.-D. (See Pl. X, fig. 8.)

The following table is of use for the males only :—

1. Claws long; frons decidedly less than the width of one eye . . . . 2.
   Claws very short, barely exceeding half the length of the last tarsal joint; frons decidedly wider than a single eye; strong fronto-orbital setae present . subgen. **Micromyiobia,** B. & B. (= **Solieria,** Stein). 4.
2. Frons very narrow at the vertex seen from above, being less than half as wide as one eye, frontalia still narrower in proportion, at its narrowest part barely half as wide as an orbit; very long claws, decidedly longer than last tarsal joint; legs also longer than in any of the other species; abdomen very yellow, with only a narrow dark streak on the 2nd and 3rd segments . . . . **inanis,** Fall. (= **longipes,** Mg.).
   Frons wider, being at least two-thirds the width of one eye; claws about as long as last tarsal joint; abdomen with more dark colour, widening out towards hinder edge of each segment in turn . . . . . 3.
3. No fronto-orbital setae.
   fuscana, R.-D., teste Villen. et Stein (= **inanis** (Fall.) auct. ?).
   Possessing fronto-orbital setae . . . . . **vacua,** Rond.
4. Legs with the femora darkened at the base, but mostly yellowish, and tibiae yellow; some yellow at the sides of the base of the abdomen.
   tibialis, v. Ros. (= **diaphana,** Rond. = **montana,** B. & B.).
   Legs much darkened, and abdomen showing little if any tendency to yellow markings . . . . . **tibialis,** v. Ros. var. (? **festiva,** Pand.).

Another difficult genus, with many names and much variation, but the capture at Aston Rowant, Oxfordshire, last summer (1927) of good series of *inanis*, Fall., and *fuscana*, R.-D., enables me now to feel pretty certain of four good British species. I had no difficulty in separating *inanis* from *fuscana*, and these two species are readily distinguished from the remainder in the male sex by the entire absence of fronto-orbital setae. *Inanis* has a very narrow frons, less than half the width of an eye, with the frontalia narrower still in proportion, being barely half as wide as one orbit, and the frons generally light-coloured; whilst *fuscana* has the frons two-thirds of eye width, the frontalia wider in proportion, being about equal to the width of the orbits, and the frons generally darkened. *Inanis* is a yellower insect, the femora nearly all yellow and the antennae bright yellow at the base, whilst *fuscana* has some dark patches on the fore femora and the antennae darker, sometimes all dark. *Inanis* too is the largest species of the genus with proportionately longer legs and very long claws. *Inanis*, Fall. (= *longipes*, Mg.), is certainly locally common, as it was in numbers at Aston Rowant; I possess, also, one male from Barmouth, and have seen in addition three males from Herefordshire, Tram Inn (Yerbury), Tarrington (Yerbury), and Swillgrove (Wood), two fine males in Mr. J. E. Collin's coll. from Chippenham, and another male from Maidstone (Sir G. F. Hampson, in Brit. Mus.). Of *fuscana*, R.-D. (= *inanis* auct.?), I had seen no British specimen until I took the long series at Aston Rowant, but I have little doubt that it will prove to be common and perhaps the commonest of the genus. *Vacua*, Rond., seems to be fairly common, although I possess no great number of specimens, but have records from widely separated localities, so that it seems well distributed.

The remaining one or perhaps two species are quite distinct from the preceding on account of the very small claws, wide frons and well-developed fronto-orbital setae; whether there are really more than one species is very doubtful, but I fancy that there is a difference in the width of the frons, the darker ones having them narrower. This seems to be the commonest of all the Myiobias in this country, and I fancy the darker ones predominate; perhaps this darkness is only the kind of thing one is used to in many kinds of insects in their more northern localities.

The females in this genus are unfortunately practically undeterminable at present; probably the long legs combined with much yellow colouring would distinguish *inanis*, Mg., as a rule; and at the other extreme the very dark coloration of legs and abdomen would indicate *tibialis*, v. Ros., but that is as far as one can go at present. This is one of those cases where it is desirable to study long series taken together at one time and place; and it should be worth while examining the genitalia. The species of the genus are very distinctive, with projecting epistoma, short antennae, reduced chaetotaxy, only two pairs on scutellum, and marginals only on abdomen, even on 4th visible segment. They are slender-looking flies with long legs and longish abdomen.

84. Rhynchista, Rond.

One species only, namely **prolixa,** Mg., but little known. I have it from Selsley, Glos., and Farningham (H. W. Andrews); and have also seen specimens from Stroud, Glos., and Bournemouth (both R. C. Bradley); Doward, Herefordshire (Dr. Wood); Berks Downs near Streatley (J. E. Collin), and Tring (A. Piffard, in Brit. Mus.). It is allied to the next species, which it resembles in size and shape but not in colour. The epistoma is very prominent; the frons narrow; the proboscis lengthened and projecting in front of the epistoma;

the male has the apical sternite developed into two conspicuous erect plates. A dark insect with the usual whitish tomentum.

85. ERIOTHRIX, Mg. (See Pl. X, fig. 10.)

Another genus with but a single British species, **rufomaculatus,** Deg., better known as **Olivieria lateralis,** F., one of our commonest Tachinids and one of the most widely distributed. It is very much attached to Ragwort, and where that flower grows it sometimes occurs so freely that I have seen a score or more on a single plant. I have it from Scotland also. Our insect appears to me to differ so much from the typical form most commonly occurring on the Continent that I think it should be distinguished by at least a varietal name. The form which appears to be according to type teste Brauer, and also teste Villeneuve (in litt.), has in the male a very narrow frons, about one-third or two-fifths of the width of one eye, and no trace of a fronto-orbital seta; and our usual form has a frons about half as wide again, more than half the width of one eye, and one fronto-orbital seta high up, where perhaps it should be called a praevertical. Our specimens in addition have shorter claws and a greater development of the dark colour on the abdomen, and look altogether darker. I called Dr. Villeneuve's attention to the differences, and he informed me that around Rambouillet both forms occur together as well as intermediates, but in this country I think that practically all are of the one form, and a long series I have from Italy seem to be all of the other one with the narrower frons. Dr. Villeneuve suggested the name **monochaeta** var. nov. for our variety, and I propose to adopt it, whether it is to be regarded as a distinct species or not. The bright rufous sides to the abdomen, short stalk to 1st posterior cell, short antennae, the two joints about equal, lengthened proboscis, short stumpy cubital appendage to the bending of the 4th wing-vein, etc., are distinctive.

86. LOPHOSIA, Mg.

One species only, **fasciata,** Mg., a striking and distinctive species with the basal portion of the long slender abdomen constricted in a hymenopterous fashion as in the species of the well-known genus *Ocyptera,* to which it is closely related. It is all dark, unlike the *Ocyptera* species, which show much rufous, the abdomen being shining black with fine silvery bands on fore edges of segments, and the wings having a conspicuous dark fascia on each. The male antenna has the 3rd joint much enlarged and triangular in shape. It appears to be a very rare species, and it is not one likely to be readily overlooked. The first was found by Mr. F. C. Adams in the New Forest in 1901, where he took several other specimens in that and succeeding years; then Mr. Verrall obtained it at Wormsley Park, Bucks, where I also got one on a subsequent visit, and where it seems established; and it was also taken at Parknasilla, Co. Kerry, by Col. Yerbury, curiously enough only two days after the capture of the first specimen by Mr. Adams. This fine insect is well represented on Pl. III, fig. 1, in the volume of the *E.M.M.* for 1913. I have last year (1927) taken two more specimens at Aston Rowant, Oxfordshire, only about three miles away from the Wormsley locality.

87. OCYPTERA, Latr.

1. Abdomen armed with marginal macrochaetae only on the 1st and 2nd segments, just one pair on each; scutellum with three pairs of the same on the edge . . . . . **brassicaria,** F.
2. Abdomen with three pairs of macrochaetae on each of the 1st and 2nd segments, and only one pair on the edge of scutellum . **interrupta,** Mg.

A genus of striking-looking flies of hymenopterous appearance bearing definite resemblance to some of the fossores with red-banded abdomens. As in the preceding genus the long slender abdomen is constricted at the base, but in this it is largely red. *Brassicaria* is perhaps the best-known species in the genus and also one of the largest. It is uncommon in this country, but Col. Yerbury took a series at the Lizard in 1896, some of which are in the British Museum, and others in the Verrall collection, and Mr. H. W. Andrews found it at Glengariff in Ireland in 1908, one of his specimens being now in my collection. In the Verrall List *cylindrica*, F., occurs, but I think the occurrence of that species in this country needs confirmation as colour variations of *brassicaria* may have been mistaken for it. The extent of the development of the black and red on the abdomen varies greatly in these species, and as various writers have endeavoured to separate them on colour characters alone there has been some confusion. *Cylindrica*, now known as *boscii*, R.-D., shows parallel variation with *brassicaria*, but can be distinguished by the presence of hairs and bristles on the apical portion of the 2nd ventral segment, these being absent in *brassicaria*; the wings of *boscii* have yellow bases and darkened outer halves, the two colours sharply contrasted, whilst in *brassicaria* the wings are nearly clear; further, the 2nd antennal joint in *brassicaria* is shortened to about half the length of the 3rd, in *boscii* being distinctly longer than the half, and thinner too. *Boscii* may still prove to be British, but I do not think we can yet regard it as such.

Ocypterula pusilla, Mg., also occurs in the Verrall List in italics, but I suspect that the supposed British *pusilla* were really *interrupta*, Mg., a species similar in size and appearance. *Pusilla* in the male possesses one unusual and distinctive character, the end of the arista being widened into a leaf-like termination; so far as I know there is no other species with this development. It also has only one pair of marginal macrochaetae on the abdominal segments, and one pair only on the edge of the scutellum, so that even without the help of the male antennae it should be recognisable. Of *interrupta* I took two male specimens on Studland Heath on May 31, 1912, and have since seen a pair from Abbotts Wood in the Verrall collection taken in 1867. I do not think that *pusilla* is so likely to occur here, as it seems to be a southern insect.

88. Mintho, R.-D.

There are usually supposed to be two distinct species in this genus, which is unmistakably characterised by the peculiar narrowed abdomen, that has the appearance of having been pinched sideways, the character chiefly relied upon for their separation being the presence or absence of a costal seta. The names most frequently given to them are *compressa* (F.) and *praeceps* (Scop.), but unfortunately whilst Schiner and others, including Stein in his last work, use *compressa* for the species without a seta, Brauer, Rondani and others use it for the one with a seta; and Schiner uses *praeceps* for the species with a seta and Brauer and Rondani for the one without, so that much confusion results. I feel by no means sure that the two species are distinct, as apart from the costal thorn the differences are chiefly in details of colour, and I feel sure that colour characters are not reliable in this case. Stein, however, adds that in the form with a costal thorn, which he calls **rufiventris,** Fall., the frontal bristles are strong and increase in length from front to back, whilst in the other they are short and decrease in size from front to back. Anyhow, I feel sure that we have but one species here, the one with a costal thorn, for which the name **rufiventris** is the most satisfactory; and as Stein says that the other is a southern

insect and apparently very rare, I think we may say that it is unlikely to prove British, although it occurs in some British lists. Rondani described a third species, *lacera*, which, however, was probably only a dark variety of *rufiventris*. Our species, however, certainly tends to run nearest to *lacera*, so that perhaps we might call it **rufiventris,** Fall. var. **lacera,** Rond. It is uncommon, and I have never met with it. Mr. F. B. Jennings, however, found it in the Lea Valley Marshes and neighbourhood; Mr. H. W. Andrews at Eltham; Mr. F. Jenkinson and others have taken a number at Cambridge, and there are others in the Brit. Mus. from Tring (W. R. O. Grant), and Epping Forest (F. B. Jennings). Mr. J. E. Collin has a good series from Newmarket, where he tells me that he finds it not uncommonly late in the year in his own garden and house.

89. PHYLLOMYIA, R.-D.

One fairly common, and well-known species, **volvulus,** F., which runs about leafage vibrating its wings like a Hymenopteron, and has a somewhat elongated abdomen which perhaps may be said to give it some resemblance to a black fossore. It is a medium-sized shining black insect, with no rufous markings on body or legs, but conspicuous patches of white tomentum. It has small eyes; some hairs on the wide genae; fronto-orbital setae in the male; abdominal discal setae; three D.C.; the 4th vein bent forward in a very shallow curve. It never seems to occur in any numbers, but is widely distributed, though I have no record from anywhere further north than Notts.

90. THELAIRA, R.-D.

An equally well-known and still commoner species, **nigripes,** F. (= **leucozona,** Panz.), a larger insect with long legs and, like the last, black with conspicuous patches of white tomentum. The head is characteristically semicircular as seen in profile, with narrow genae, orbits, etc.; the antennae small, the 3rd joint twice as long as the 2nd and very thin; the arista very plumose. It is widely distributed.

91. REDTENBACHERIA, Sch.

One species only, **insignis,** Egg., extremely rare. I have seen a male in the Verrall collection from Lyndhurst, and a female apparently bred but without history, and there is one female in the British Museum taken by Col. Yerbury also at Lyndhurst, but I know of no others. It is a distinct species with very wide lateralia, these being equal to more than half eye height, and with the vibrissaria nearly on a level with the lower eye edge, and accordingly a long way above the level of the lower edge of the head. It has a shining black abdomen with contrasting all-yellow legs; the antennae too are nearly all yellow, and thin and somewhat projecting.

92. TRIXA, Mg.

1. Wings with the cross-veins strongly margined with dark colour so that the wings appear spotted . . . . . **oestroidea,** R.-D.
2. Wings quite clear . . . . . **alpina,** Mg.

Large species, very rotund. *Oestroidea* not only has spotted wings but also tessellated and variable abdominal shadings; it is not uncommon, and I have a number of records for it including Rannoch, Logie, etc., in Scotland. *Alpina* is a rare species, which differs in the sexes, the male having ferruginous sides to the abdomen, and a dark and reddish appearance; while the female has no ferruginous on the abdomen, and has bands of grey on the front margins of the

segments, the grey being a bright soft almost blue-grey, giving a tone to the whole insect. Formerly the two sexes appeared in our lists under separate names as *ferruginea*, Mg., and *grisea*, Mg., but I think there can be no doubt about them representing as stated only the two sexes of one species, now called *alpina*. Nearly all the specimens I have seen are from the New Forest, but I have also seen a female from Tunbridge Wells (Col. Nurse); a male from Pentelow, Herefordshire (Dr. Wood); several from near Oxford at Shotover, etc. (A. H. Hamm); and Mr. J. Collins has reported it from Cothill, Berks. Apart from its large size and rotund form the genus is easily recognised by its very short antennae, consisting of two nearly equal joints, which are entirely yellow; the face is "keeled"; the palpi are thick and club-like.

93. Atropidomyia, B. & B.

One of the long-legged Dexiid type of insects, above middle size, of which this genus is the first of a series. There is only a single species, **irrorata,** Mg., apparently very rare. I took a single specimen, a female, in Ran Dan Woods, Worcestershire, on August 19, 1898, and this remained the only one of which I had any knowledge until Major Austen recorded the species under the generic name *Billaea* in *E.M.M.*, 1922, pp. 182–3. He reported it as having occurred at Bagshot, Abbey Wood, Kent, and at Oxshott, and Leatherhead, Surrey. It has a shortened face, indefinitely carinate; short antennae, 3rd joint twice as long as 2nd; clavate yellow palpi in female; four D.C.; scutellum with crossed apicals, two pairs laterals and a pair of discal setae; and abdomen with marginal macrochaetae only. The 1st posterior cell is open.

94. Estheria, R.-D.

1. With four postsutural dorso-central bristles; stalk of 1st posterior wing-cell equal to at least one-quarter the length of the subapical cross-vein; tomentum on the abdomen even without variable shadings. **bohemani,** Rond.
2. With three dorso-centrals only; stalk of 1st posterior wing-cell not as long as one-sixth of the subapical cross-vein; tomentum on abdomen with variable shadings . . . . . **cristata,** Mg.

Species of typical Dexiid appearance similar to the last genus, rather large, with small eyes and wide genae and lateralia and shortened face; distinguished from the last genus by possessing discal macrochaetae, and by the 1st posterior cell being closed and stalked. They are species of brownish-grey coloration, the abdomen all dark, the legs dark with reddish tibiae. Neither species is common, but I found *cristata* once near to Matley Bog in the New Forest in some numbers, and it was Dr. Wood who first found it in Britain, in Herefordshire, where he took a number of specimens. Others I have seen were from Wyre Forest (R. C. Bradley); Ipswich district (C. Morley); Crowborough (F. Jenkinson), and Tunbridge Wells (Col. Nurse), etc. *Bohemani's* standing as a British insect rests upon one specimen in the Verrall collection taken in Sutherland by W. A. Vice, I think in 1877. The two species are very much alike, but the characters above quoted should be sufficient to ensure recognition.

95. Dexia, Mg.

1. Abdomen with distinct narrow dark hind-marginal bands on each segment . . . . . **vacua,** Fall.
2. Abdomen with no distinct hind-marginal bands . . . . . **rustica,** F.

Well-known and conspicuous species, large insects with long legs, and predominantly fulvous colour, especially in the males. The face is markedly carinate; the antennae very short; the arista very plumose; abdomen with marginal and discal setae; the females have the abdomen dark and covered with yellowish tomentum. Both are widely distributed and usually found in some numbers where they occur. *Vacua* is the more abundant, and I have a number of records from the Trossachs southwards. Of *rustica* I have fewer records, but they include Boscastle; Barmouth; Tenby; New Forest; Herefordshire (Dr. Wood); Cambridge (Dr. D. Sharp), etc.

97. **Dexiosoma**, Rond.

One species only, **caninum,** F., one of our commonest Tachinids. It occurs very freely on bracken in semi-wooded places, and is a large and conspicuous species, with very long body and legs, and an unmistakable face, in which the facialia converge and almost touch and run together for a space equal to about one-third the total length of the face. There are three or four strong bristles on each side at this point. There is no carina on the face, which is deeply hollowed out. Long yellow legs; small yellow antennae, etc.

98. **Prosena**, St. Farg.

1. Abdomen at sides decidedly fulvous, with a narrow central dark line in the male; in the female uniformly covered with yellowish tomentum on a dark background . . . . . **sybarita,** F.
2. Abdomen uniformly covered with ashy-grey tomentum showing very slight traces of fulvous sides or dark central line in the male; the female I do not know. A smaller insect and not quite so plump. **luculliana,** Rond.

Sybarita is a well-known insect with the slender form and long legs of the preceding genera, but recognisable at once through its long projecting thin pointed proboscis. Common locally, I have seen it in abundance at West Runton, Norfolk, and have also met with it at Barmouth, Criccieth, etc., and have further records from Glengariff, Ireland (H. W. Andrews), Oxford (A. H. Hamm), Holne (Col. Yerbury), Mildenhall, etc.

Luculliana is perhaps only a variety of *sybarita*, and indeed my friend Dr. Villeneuve so regards it; but the two small series of it which I have examined—one from Beesfield Valley, near Farningham, Kent (H. W. Andrews), three males, which are now in my possession, and the other from Tring (Piffard), four males and one female in the Brit. Mus.—were all exactly alike, with no variation of importance and no intermediate forms; and a long series which I took at West Runton of typical *sybarita* were equally constant and included no specimen like the *luculliana*, so that it would seem to be a distinct form and worthy of a separate name.

99. **Dinera**, R.-D.

One British species, **grisescens,** Fall., similar in type to those of the preceding genera, but smaller. Abdomen covered with uniform ashy-grey tomentum; no macrochaetae at all on the 1st visible segment, a pair of marginals only on 2nd, no discals even on 4th; scutellum with small crossed apical setae and two pairs laterals; three D.C.; 1st posterior cell closed at margin; very small antennae; yellow palpi, tibiae, etc. Not uncommon; I have a number of records, all from the more southern counties, West Runton, Norfolk, being the

most northerly. (I have since seen one in Mr. J. E. Collin's coll. from Blairgowrie.)

100. **Myiocera**, R.-D.

Again only one British species, **carinifrons,** Fall.; not common, but widely distributed. It seems to be a late summer or autumn species, and is perhaps commoner than it seems but overlooked through its late appearance. I have found it fairly commonly in Wyre Forest in the latter half of August and in September, and have one male from Rannoch and records from various other localities. It is again one of the long-legged and long-bodied species of the Dexiid group, the last to be mentioned here. It is dark grey with abdominal tomentum showing shifting markings; marginal macrochaetae on 1st segment; 1st posterior cell open; very prominent facial carina; antennae a little lengthened, 3rd joint two and a half times the length of 2nd.

101. **Rhinomorinia**, B. & B.

An old specimen in the Verrall collection taken at Arran, 16.vi.82, appears to belong to the little-known species **puberula,** Zett. It is a species about the size (6 mm. long) and appearance of *Phryxe vulgaris*, Zett., but fairly well characterised. The genae are wide, about twice as wide as the antennae, and the lateralia are still wider and also long, and the epistomal edge is prominently curved forwards. The upper part of the genae is clothed with short setose hairs; frons narrow, about one-quarter of eye width; the medianae are conspicuously rufous and there is a touch of rufous about the 2nd joint of the antennae, but all the rest of the insect is black, with a thin even coating of tomentum on the thorax and abdomen through which the usual markings show very faintly, only a narrow dark central line and narrow hind margins showing on the abdomen; there are small discal setae on 3rd and 4th visible abdominal segments; the antennae are short, the 3rd joint less than twice as long as the 2nd, and they are set low down on the head, at a point below the eye middle; the eyes bare. It appears to be a very little-known species, apparently of northern distribution, so that it may prove to be well established in Scotland.

102. **Plesina**, Mg. (See Pl. IX, fig. 5.)

One species, **maculata,** Fall. A species which runs about foliage with vibrating wings somewhat after the manner of some fossorial Hymenoptera, which it resembles a little with its narrow shining abdomen; with its spotted wings it is a fairly distinct species. I have only found odd ones, but have a number of records, including Inverness (F. Jenkinson) and the Trossachs. It has a very rounded front to the head; very short antennae, the 2nd and 3rd joints nearly equal; very small palpi; the scutellum bears a pair of crossed apicals and only one strong lateral each side; only small marginal macrochaetae on the black shining abdomen. The long-stalked 1st posterior cell and yellow and blackish markings of the wings are the most distinctive characters.

103. **Stevenia**, R.-D.

One rare species, **umbratica,** Fall. (= **simplicissima,** Lw.), of which I know very little. There is one specimen over the name *simplicissima* in the British Museum from Belvedere (Col. Yerbury), but I have not critically examined it. It is a black species with a little tomentum on fore edges of segments, and marginal macrochaetae only; long-stalked 1st posterior cell; 3rd longitudinal wing-vein with a row of setae on basal portion; strong genal setae; fronto-orbital setae in the male sex; three D.C.; scutellum with strong crossed apicals, and only one other pair of marginals; the femora thickened.

104. PTILOCERINA, Macq.

This genus is only separable from the former through the possession of discal macrochaetae, indeed Stein sinks it altogether and includes the species in *Stevenia*. Like *umbratica* the species are of medium size, with long-stalked 1st posterior cell and strong genal setae. We seem to have one species only, which is presumably **atramentaria,** Mg., although the variation in my series from continental as well as British sources makes me wonder if there may not be more than one species under that name. Our specimens are smaller than some of my continental ones, being about 8 mm. long, and even in the males the abdominal pruinose bands are not very strongly developed, and in the females practically not at all, the abdomen being black and shining; whilst some of my continental ones are 10 mm. long, and with much development of the tomentum on the male abdomen, and yet I cannot separate the two forms at present upon any sound specific characters, and neither form agrees with any of the other known allied species. It is not a common British insect in my experience, although Mr. J. Collins tells me that he has taken altogether about thirty specimens at Yarnton near Oxford, and he kindly gave me two pairs. I have a male also from Lea Marshes (F. B. Jennings), and have seen another from Tunbridge Wells (Col. C. G. Nurse). Mr. Donisthorpe has recorded having bred it from *Oniscus asellus*, L., and there are specimens in the British Museum from Belvedere (Col. Yerbury), etc.

105. STYLONEURIA, B. &. B.

One species, **discrepans,** Pand., nearly allied to *Phyto*, in which genus it is placed by Stein. Specimens were identified for me by Dr. Villeneuve. It has a short-stalked 1st posterior cell, and rather rounded bending to the 4th vein; the abdomen is very tomentose, with no macrochaetae on the 1st segment and marginals only on the rest; a few fine hairs on the genae; small antennae, with the 3rd joint about half as long again as the 2nd, and conspicuous genitalia. Apparently a rare species of which I know very little. I have one male from St. Ives, Cornwall, and have seen two more from Salcombe, Devon (Col. Yerbury), in the British Museum collection, and another (all being males) from Padstow (C. G. Lamb) in the Cambridge Museum. Mr. J. E. Collin has a pair from Penzance, 9.vii.71, a male from Slapton, 29.viii.84, and another from Gunwalloe, Cornwall (Col. Yerbury). Thus all the records are from the West Country and the sea coast. The Rev. A. Thornley has found this to be a common species at St. Ives, Cornwall.

106. FRAUENFELDIA, Egger.

One distinct little species, **rubricosa,** Mg., not common but widely distributed. I have it from West Runton, Wyre Forest, and Studland Heath, and have seen others from Criccieth (R. C. Bradley); Felden, Herts (A. Piffard); Monifieth (A. E. J. Carter); New Forest (Dr. Sharp); Kirtling, Cambridgeshire (J. E. Collin), and Nottingham (Prof. J. W. Carr), etc. It was first recorded by Austen from Tring in *E.M.M.*, 1898, pp. 81–3. It is a species with setose genae; shortly plumose aristae; 1st posterior cell closed but not stalked; the bending of the 4th vein rounded; the genitalia in male very conspicuous, the apical sternite being enlarged into a pair of prominent upstanding lamellae; abdomen with hind-marginal setae only; tibiae yellow.

107. Melanophora, Mg.

One species, **roralis,** L., not common but widely distributed. I have it from West Hide, Herefordshire; New Forest; Hunstanton, and Stokenchurch; and have seen others from the Lizard (Col. Yerbury); King's Lynn (E. A. Atmore); Cambridge (many specimens, F. Jenkinson); Oxford (A. H. Hamm), etc., etc. It is a small black insect, with dark wings, which in the females have conspicuous light-coloured tips, which are very distinctive. *Atra*, Macq., is apparently only a synonym. One male which I examined, taken in the New Forest by Dr. D. Sharp, was larger than usual, and seemed to me to have a proportionately wider frons. It is a species with a distinctive head, rounded in profile; the frons wide, nearly as wide as both eyes and with a row of fronto-orbital setae in both sexes; the antennae inserted very low, about opposite to the lower fourth of the eye height; and the lateralia very wide, equal to about four-fifths of the eye height. The 1st posterior cell has a very long stalk, and the cell itself is small. The chaetotaxy is much reduced.

108. Phyto, R.-D.

Melanocephala, Mg., the only British species, is a common, but not abundant one, of medium size and undistinguished appearance, characterised by a rounded head and shortened face; short antennae with 2nd and 3rd joints of nearly equal length; setose genae; three D.C.; scutellum with strong crossed apical setae, and two pairs of strong laterals; abdomen with discal and marginal macrochaetae; male with dense ashy-grey tomentum with conspicuous dark central line and dark hind margins; female with much less tomentum and abdomen mainly shining black; 1st posterior cell short-stalked. I have many records of its occurrence, but nowhere further north than King's Lynn (E. A. Atmore).

109. Rhinophora, R.-D.

Lepida, Mg., a small shining black species often occurring in abundance and widely distributed. The sexes were given separate names in earlier lists, the male *Clista moerens*, Mg., and the female *Clista aenescens*, Zett., the male having conspicuous bands of silver tomentum and the female an entirely shining black abdomen. It has rather a characteristic produced epistoma, etc., the succiput being straight and long, the peristomal edge curving upwards abruptly in front to the epistoma, which is projecting and upcurved; these seen from in front form a prominent arch; the frons is narrow in the male and the upper three or four pairs of frontals are all backwards curved; the 1st posterior cell is stalked; the scutellum has a pair of strong apical setae, and one other large bristle on each side only.

SARCOPHAGINAE.

110. Tephromyia, B. & B.

The first genus of the *Sarcophaga* group. One species only, **grisea,** Mg., apparently very rare. I took it once on Studland Heath, where I obtained three males on June 9, 1919, and the only other British specimen of which I have knowledge is a single female in the British Museum, taken at Lyndhurst by Col. Yerbury. It is readily distinguished by the uniform covering of yellowish tomentum, which in some specimens, and especially females, leaves no markings at all showing on the abdomen. When fully developed the markings found in some specimens consist of three rows of longitudinal spots, which are

quite fixed and do not change when viewed from varied positions, like those of the species of the genus *Sarcophaga* itself. These markings, however, tend to disappear and in the males to be represented by a single central line, and in the females by no trace at all. The species may be compared with *Sarcophila latifrons*, Fall.; but *Tephromyia* has a narrow frons in the male and no fronto-orbital setae; the frons in the female, though wide, is only about equal to eye width; the female has the apical ventral segments developed into a striking concave shining red-brownish plate; the arista has conspicuously long ciliation, more like that of a Calliphorid than of a Sarcophagid; genae setose; no discal setae on the abdomen.

111. SARCOPHAGA, Mg.

Table of males only :—

1. Genital segments (that is the apparent 5th and 6th abdominal segments) mainly red . . . . . 2.
   Genital segments all black or practically so . . . . . 8.
2. The frontal bristles run in straight and parallel lines, showing no tendency to curve outwards towards the eyes at the lower ends. **striata,** F. (**haematodes,** Mg.).
   The lines of the frontal bristles curve outwards in front . . . . . 3.
3. Longitudinal wing-veins one and three setigerous . . . . . 4.
   Longitudinal wing-vein three only setigerous . . . . . 5.
4. Very characteristic genitalia; the forceps seen sideways straight and apical portion thin, becoming so abruptly just beyond the middle, so that basal portion appears about twice the width of end part. Hind tibiae usually have no fringes of long hairs or but very slight ones; 1st vein nearly always with a distinct row of setae; the species is variable, however, and no character is quite reliable excepting those of the genitalia . **haemorrhoa,** Mg.
   The forceps have the apical portion curved inwards, and this portion gradually tapered down to a point. Hind tibiae usually possess strong fringes of long hairs on the inner side, but in small specimens they are little developed; no setae on 1st vein, or at most only two or three. **frenata,** Pand.
5. Thorax with four or five D.C., of which the two or three front ones are sometimes small and thinner than the others . . . . . 6.
   Thorax with three strong D.C. . . . . 7.
6. Praescutellary bristles failing (this is the pair usually to be found just in front of the scutellum, between the two rows of D.C.). Genitalia distinctive, the forceps seen from the side thin and finely pointed and somewhat in an **S** form . . . . . **haemorrhoidalis,** Mg.
   Praescutellary bristles present. Forceps seen sideways thick and blunt, the tip abruptly sloped to a point, and with a dip in the upper edge before the end . . . . . **falculata,** Pand.
7. Second abdominal segment with marginal setae; 1st longitudinal vein often bearing a few setae . . . . . **frenata,** Pand.
   Second abdominal segment with marginal setae failing; 1st vein with no setae . . . . . **ebrachiata,** Pand.
8. Genital segments (the apparent 5th and 6th abdominal segments) smaller and less conspicuous than in other Sarcophagas and less produced, and bearing a curious warty process on each side of each; abdominal markings fixed, not varying with the point of view (not a true *Sarcophaga*; see the genus *Agria*, R.-D.) . . . . . **Agria mamillata,** Pand.
   Genital segments large and prominent; no warty processes at the sides; abdominal markings varying with the point of view in the usual tessellated pattern . . . . . 9.

9. Thorax bearing no praesutural acrostichal setae . . . . . 10.
Thorax bearing distinct praesutural acrostichal setae . . . . . 25.
10. Wings with the 1st longitudinal nervure bare . . . . . 11.
Wings with the 1st longitudinal nervure bearing a row of small setae along the basal portion . . . . . 23.
11. Middle femora with a conspicuous patch of golden pubescence towards the tip in front . . . . . **sinuata,** Mg.
Middle femora with no such golden pubescence . . . . . 12.
12. Thorax bearing four or more postsutural dorso-central setae, though the front two or more are often small . . . . . 13.
Thorax with three such dorso-centrals only, and all well developed . . 17.
13. The terminal sternite or ventral segment produced tooth-like, forming a conspicuous shining prominent sharp point . . . . . **aratrix,** Pand.
No such projection on the sternites . . . . . 14.
14. Ventral segments throughout, and notably the 4th, with shaggy prominent pubescence; the largest British species; setae and hairs throughout strongly developed; a rather blacker-looking insect than the familiar *carnaria,* L. . . . . **scoparia,** Pand.
No conspicuous development of hairiness on the ventral segments . . . 15.
15. Abdomen with marginal setae on the 2nd segment . . . . . 16.
Abdomen with no marginal setae on the 2nd segment . . **teretirostris,** Pand.
16. Oedeagus terminates with two processes suggestive of a thumb and finger; the outer one large and bent abruptly about the middle; the inner one much smaller and not in contact with the other. Of the two small curved hook-like processes near the base of the oedeagus, the inner one, that is the one curved up nearest to the dorsum, is much longer than the other and indented at the tip . . . . . **carnaria,** L.
Oedeagus with similar terminal processes, but the outer one not bent abruptly but gently curved, and the inner one large, as large as the outer one, and in close contact with the same, filling up the hollow of the curve. The two basal hooked processes about the same size as one another . . . . . **vicina,** Villen.
Note.—The above two species are so much alike that I know of no means by which they can be separated excepting by examination of the genitalia, which really require drawings for full appreciation.
17. The genital segments unusually slender and much longer than wide; the 1st when fully seen nearly if not quite twice as long as wide . **pumila,** Mg.
The genital segments of the usual proportions, the 2nd one shorter than its width, and the 1st not much longer . . . . . 18.
18. Abdomen with no marginal setae on the 2nd visible segment . . . . 19.
Abdomen possessing marginal setae on the 2nd visible segment . . . 20.
19. Frons at its narrowest part fully four-fifths of the width of one eye. **melanura,** Mg.
Frons at narrowest part barely three-fifths of eye width.
incisilobata, Pand. (**striata,** Mg. nec Fab.).
20. Frons wide, at narrowest part about four-fifths of one eye width . **filia,** Rond.
Frons narrow, about three-fifths of eye width . . . . . 21.
21. Depression on 1st visible abdominal segment does not reach the hind margin, from which it is separated by a distinct broad level space.
crassimargo, Pand.
The depression on 1st segment extends to hind margin . . . . . 22.
22. The species with the narrowest frons in this group, barely two-fifths of the width of one eye . . . . . **agnata,** Rond.
Frons wider, about three-fifths of eye width . . . . . **rosellei,** Böttch.
Note.—The above three species again are so nearly alike as to require examination and study of the genitalia from drawings, for their certain differentiation.

23. Frons wide, at its narrowest part nearly equal to the width of one eye. **setipennis,** Rond.
Frons narrower, barely equal to half the width of one eye . . . . . 24.
24. Claspers of the genitalia seen in profile straight, tapered and wedge-shaped; the dark markings on the abdomen tend to spread out so as to give a dark shining effect to almost the whole abdomen . . . . **dissimilis,** Mg.
Claspers seen from the side narrow abruptly towards the apex and bend inwards . . . . . **offuscata,** Sch.
25. Frons wide, nearly equal to the width of one eye . . . . . 26.
Frons narrow, at narrowest part only about half eye width . **clathrata,** Mg.
26. Oedeagus with end process lengthened and blunt, a curved horn-like process on each side. (Frons said to be half eye width against two-thirds in *nigriventris*, but I could not see much difference in this respect in the two specimens examined; also Stein says apical scutellary bristles are parallel in this species and crossed in *nigriventris*; but the only safe characters are those of the oedeagus, which are clear and good.) **villeneuvei,** Böttch.
Oedeagus with end process very short and pointed, and no curved horn-like or similar side processes . . . . . **nigriventris,** Mg.

This genus is familiar to most entomologists. It is fairly clearly defined, with its arista feathered at the base only and bare on the apical portion; its genae setose; its abdomen with its glancing tessellated markings varying with every change of position; the bending of the 4th vein with cubital appendage, and its conspicuous genital segments. One species, *carnaria*, L., is one of the commonest, most widely distributed and best-known of the TACHINIDAE; the others are similar to it and many of them also abundant.

The genus was very little understood, and all identifications were in a state of great confusion, until the male genitalia were studied, when it was found that these parts differed strikingly, indeed extraordinarily, and provided excellent specific characters which have since enabled a large number of species to be clearly defined. Verbal descriptions of the genitalia are very ineffective, and for reliable determinations drawings of all the species are necessary, but I have not ventured to provide such here, and if any student wants to investigate beyond the possibilities of the above tables he should consult Böttcher's papers in the *Deutsche Entom. Zeit.* for 1912 and 1913. Fortunately study of the genitalia has revealed the fact that many apparently trivial external characters are more reliable than might have been expected, and it has been possible to produce a table which should enable most species to be identified without examination of the genitalia, although in a few cases this is impossible. The well-known *carnaria*, L., for example, has proved to have a "double," namely *vicina*, Villen., which is so like it, that I know of no means of recognition other than comparison of the male genitalia, and as both species are extremely common, if not quite equally so, it is necessary to make sure in every case. Further, it is wisest to dissect out these parts in the case of every specimen of the genus, as only in that way can one get certainty, and there are probably other species to be detected yet. It is a simple matter with fresh specimens to draw out the apical segments with the oedeagus and claspers and to pin them out until set and dry; or to remove them altogether and to gum them to the card or label attached to the insect. The females are not yet sufficiently known, though the characters given in the table for the males will enable many to be identified; but, in such cases as that of *carnaria* and *vicina*, no means of separating the females have yet been discovered. Incidentally the female genital segments do vary amongst the species and may ultimately help towards

a table of the species in this sex. Further, it is necessary to point out that the chaetotaxy is not always the same in the female as in the male of the same species, in particular the abdominal setae tending to be reduced.

Most of the species are more or less common, but a few are not yet much known as British insects; of *agnata*, Rond., for example, I only know of odd specimens from Lyndhurst (Dr. Sharp and F. Jenkinson), and Oxford (A. H. Hamm); *aratrix*, Pand., from the New Forest, and Selsley, Glos., and from near Oxford (A. H. Hamm); *ebrachiata*, Pand., from Stradbally, Ireland (H. W. Andrews), and Amberley, Glos. (H. Bury); *falculata*, Pand., from a single male from Nottingham (T. M. Robinson per Prof. Carr), and another from Oxford (O. W. Richards); *sinuata*, Mg., one male from Chalford, Glos., one from Moccas Pool, Herefordshire (Dr. Wood), and one recorded by Mr. G. H. Verrall, *E.M.M.*, 1911, p. 79, from Mildenhall, Suffolk, also Mr. J. Collins tells me that he took it near Oxford in 1926; *villeneuvei*, Böttch., two males from Yarnton near Oxford, taken 9.viii.25, by Mr. J. Collins.

112. Agria, R.-D.

One species, **mamillata,** Pand., which has usually been included in the genus *Sarcophaga*, and is so placed in the Katalog, but which differs materially in the genitalia, and also lacks the typical glancing variable abdominal markings of that genus, having fixed distinct spots instead. In the male sex *mamillata* is easily recognised by the wart-like protuberances on the genital segments, though there is a closely allied species, *affinis*, Fall., which may even prove to be only a form of *mamillata*, but has not yet been recorded from this country, and in that these protuberances fail. In both sexes the genal setae are reduced to a row of short fine hairs; the abdominal markings form three longitudinal rows of spots, which vary only a little from different points of view; the central row forms practically a dorsal line, the side ones being roundish. I have regarded this species for some time as being not congeneric with the Sarcophagas, and am now satisfied to follow Stein in his use of Desvoidy's name *Agria* for it. It is apparently rare, and a pair taken by Mr. A. H. Hamm *in cop.* in his garden at Oxford are the only British specimens of which I know.*

113. Sarcophila, Rond.

One species only, **latifrons,** Fall.; it is similar to *Tephromyia grisea*, Mg., in its grey coloration with dark abdominal markings, but is easily recognised in the male sex through the wide frons with fronto-orbital setae, and the female too has a much wider frons than in *grisea*, it being about half as wide again as one eye; the abdominal markings are always strongly developed, forming three longitudinal rows. This seems to be a seaside species; the Rev. A. Thornley tells me that it is common at St. Ives, Cornwall, and he has kindly sent me specimens from thence; and others I have seen were from Padstow (C. G. Lamb), Felixstowe (A. Piffard), Torcross (Yerbury), Christchurch (Yerbury), and Porthcawl (Yerbury).

114. Helicobosca, Bezzi.

One species only, **distinguenda,** Villen., a large strongly developed species, not unlike *Sarcophaga carnaria*, L., but abundantly distinct, and not a true Sarcophagid. It has all the macrochaetae very thick and large; there are three or four conspicuous ones on the genae, four D.C., four pairs of marginal scutellars, and marginals only on the abdomen; the palpi are large and bright

* This year (1928) Mr. Hamm has taken a long series in the same garden.

yellow, all the rest of the insect being dark. This is the species which has been known as *Theria muscaria*, Mg., but two distinct species have been mixed until recently, one with narrow frons in the males without fronto-orbital setae, which is our species, and the other with frons in males as wide as in the females and possessing fronto-orbitals, which so far does not seem to have occurred here. Villeneuve has restricted the name *muscaria*, Mg., to the species which does not occur here and proposed *distinguenda* for ours. It is apparently rare; I have one male from Shaldon, Devonshire, and have seen two more taken at Cirencester by the Rev. A. Thornley.

115. **Nyctia**, R.-D.

One species, **halterata,** Panz., a well-known shining black insect with the fore margin of the wings much darkened. Abdomen shining, quite devoid of tomentum, with marginal setae only; three D.C.; the scutellum with a pair of crossed apicals and one other pair of marginals only; the 4th longitudinal vein strongly incurved at the bending, with a long cubital appendage, and the vein reaching the costa some distance from the wing-tip; genae setose; 3rd wing-vein also setose as far as discal cross-vein. It is common and I have records from many localities, but from none further north than Nottinghamshire.

116. **Morinia**, R.-D.

One species, **nana,** Mg., perhaps the smallest British Tachinid. A narrow-bodied, narrow-winged species, with the 4th longitudinal so little bent forwards at the tip as to mislead and cause it to be taken for an Anthomyiid, especially as it folds its wings over the abdomen, and does not usually extend them in the typical Tachinid fashion. It has a very narrow frons in the male, narrow genae also, and those bare; the setae throughout are more like hairs than bristles, and not numerous. It can often be found in the net after sweeping grass and herbage, and is probably very common and widely distributed.

117. **Medoria**, R.-D.

One species only, **anthracina,** Mg. (= **digramma,** B. & B. nec Mg.), a small species with the abdomen of the male very narrow and tapered, that of the female being wider. Fourth wing-vein very gently curved forwards; antennae small, 3rd joint very thin; head somewhat rounded in front; genae bare and very narrow, lateralia also narrow; three D.C.; scutellum with three pairs of marginal setae; abdomen with discal and marginal setae, and conspicuous narrow silvery fore margins. It seems to be a rare species. I possess one male only, taken on samphire at the Lizard, and have seen one other, taken at Torcross by Col. Yerbury; Mr. Collin has a female, taken at Laughton, Sussex, 5.vi.88. Though normally possessing discal setae, according to Dr. Villeneuve these sometimes fail in the females.

118. **Engyzops**, Rond.

Another single species, **pecchiolii,** Rond., an uncommon one, of medium size and typical Tachinid appearance. Head rather rounded in front; genae hairy; arista plumose at base; 4th vein angularly bent but bluntly so; abdomen with slight brownish pruinosity; no discals on 2nd visible segment, but irregular ones on 3rd; three D.C.; three pairs marginals on scutellum. I have it from Cranham Woods, Glos., Wormsley, Bucks, and Bagley Wood, Oxford, and have seen others from the Doward, Herefordshire (Dr. J. H. Wood) and Headington and Hogley near Oxford (A. H. Hamm). Mr. J. E. Collin has it from Dullingham near Newmarket, and Tuddenham.

119. **Brachycoma**, Rond.

One species, **devia,** Fall., similar to those of the genus *Sarcophaga* and above middle size. Easily distinguished from a *Sarcophaga* by the bare arista. The head is squarish as seen in profile, with wide genae and lateralia, and a strong row of setae on the genae; 3rd joint of antennae about two and a half times 2nd; abdomen with marginals only; 4th wing-vein acutely bent and incurved beyond the bend, with a cubital appendage. It is fairly common, and I have numerous records, including Stradbally in Ireland (H. W. Andrews), and Auchencairn in Scotland (Cambridge Museum).

120. **Miltogramma**, Mg. (See Pl. X, fig. 12.)

1. Species of yellowish coloration, with the abdomen unspotted, but with dark flashing markings varying with the point of view; antennae with some rufous at the base; fore tarsi of the male simple, without any unusual hairs . . . . . **germari,** Mg.
2. Species of a more ashy-grey coloration, with the abdomen bearing clearly defined spots, usually three longitudinal rows of triangular markings; antennae black with at most traces of pale coloration at the base; fore tarsi in the male bearing long striking hook-tipped hairs. **punctatum,** Mg.

The Miltogrammas are characterised in particular by the constriction of the lower half of the interfacialia, the vibrissaria being placed high above the peristoma; by the failure of the usual large vibrissal setae; by all the setae, notably the frontal ones, being short. There are no discals; three pairs of scutellars; four uncertain D.C., and the males have fronto-orbitals. The species of this and some of the following genera are specially associated with fossorial Hymenoptera. *Punctatum* is a common and well-known one, perhaps the most familiar of the group, and occurs probably wherever there are sandy places frequented by burrowing Aculeates; and while the females are often to be seen following some bee to its hole, the males are to be found on flowers in the neighbourhood, especially on the ragwort. *Germari* is much less well known, but seems not uncommon. Mr. C. G. Lamb apparently found it in some numbers at Padstow in Cornwall. There is a long series of his captures in the Cambridge Museum. I have taken it in the New Forest, and have also seen others from near Oxford (A. H. Hamm), King's Lynn (E. A. Atmore), Mildenhall (Camb. Museum), etc. It seems to be common at Tubney near Oxford, where I have myself found it.

121. **Setulia**, R.-D.

One species, **grisea,** Mg., an insect very closely allied to *Miltogramma* and also to *Sphecapata*; it comes between them in size. It may be distinguished from *Miltogramma* by the possession of strong vibrissae, and from *Sphecapata* by the yellow antennae, palpi and frontalia and generally yellowish coloration. The antennae are sometimes dark-tipped in varying degrees. In typical specimens the abdominal markings appear like four rows of longitudinal spots, but these sometimes coalesce and sometimes partially fail. Mr. Hamm first sent me specimens of this species, not previously known as British, taken in the New Forest in association with *Cerceris arenaria*, L., and other species of Aculeates. Since then I have found it myself not only in

the New Forest, but at Barton-on-Sea, and have seen specimens from Lye Hill, Oxford (A. H. Hamm), Oxshott (A. H. Hamm), Padstow (C. G. Lamb) Esher Common (A. H. Hamm), and Tubney (J. E. Collin).

122. METOPIA, Mg.

1. In the male the whole of the fore half of the frons and part of the genae looks as if silver-plated, and, the profrons being very much produced, this feature is very conspicuous. In the female the profrons is less produced and the silveriness is only a little in evidence at the sides. The frontalia narrow and barely as wide as the frontorbita; the abdomen shows three clearly defined triangular spots on each segment. **leucocephala,** Rossi.
2. The male without such silveriness; the profrons is less prominent and the head is normal. In the female the frontalia is very wide, more than twice as wide as the frontorbita. There are no clearly defined abdominal markings . . . . . **campestris,** Fall.

Leucocephala is very common and is rarely absent from any dry sandy spots such as are frequented by fossorial Hymenoptera, and in particular it is abundant on sand dunes. *Campestris* is much less abundant but also rather widely distributed, and I have it from Stradbally, Ireland (H. W. Andrews), and from Aviemore, Culbin Sands, etc., in Scotland. Both species seem specially attached to bees of the genus *Andrena*. *Leucocephala* male is unmistakable with its striking frons; the others may be known by the long antennae, with the 3rd joint about six times the length of the 2nd; the strong row of genal setae, close to the facialia; macrochaetae throughout well developed, but no abdominal discals; three pairs scutellars; three D.C. The abdomen has three rows of strongly developed denticular spots.

123. SPHECAPATA, Rond.

One species, **conica,** Fall. This is another of the group specially associated with the Aculeate Hymenoptera and closely allied to *Miltogramma*, but it is a much smaller insect and readily identified on size alone, being 5 mm. or less over all. It has the same swollen-looking genae, etc., but the interfacialia is not constricted, the vibrissaria being close to the peristoma; the vibrissae are present, and all the setae rather better developed than in *Miltogramma*; in most other respects it resembles that genus. It is common enough where the smaller species of fossorial Hymenoptera make their burrows. It has also been taken in Scotland by Mr. A. E. J. Carter at Monifieth.

124. RHAPHIOCHAETA, B. & B.

A female fly recently submitted to me by Prof. Carr and taken at Fiskerton, Notts, on June 14, 1919, belongs, I feel sure, to the little-known species **Rhaphiochaeta breviseta,** Zett. It is a very distinct insect with wide genae and lateralia, or one might say with small eyes; the succiput sloping downwards and backwards somewhat after the style of the head form of *Macquartia*, and with only a short face; the arista short and stout, thickened almost to the tip; genae and eyes hairy; palpi pale; chaetotaxy strong, with discal setae on the abdomen. As Stein says it bears some resemblance to *Megalochaeta conspersa*, Mg., but the thickened seta alone distinguishes it.

125. MACRONYCHIA, Rond.

1. Smaller species (less in size than *Musca domestica*, L.), with abdomen uniformly covered with ashy-grey tomentum, and only a slight central dark line showing (no macrochaetae on 1st segment) . . . **griseola,** Fall.
   Larger species, altogether larger and more robust, at least 8 mm. long, with strongly marked denticulate spots on the abdomen . . . . 2.
2. Abdomen with no marginal macrochaetae on the 1st visible segment, and generally none on the 2nd (1st segment not lengthened, dark, with no denticulate markings, only side patches of grey tomentum; female with no projecting genitalia; male frons on each side with one clear row of frontal bristles, the two fronto-orbitals, and only small hairs in addition; alulae small) . . . . . **polyodon,** Mg.
   Abdomen with marginal macrochaetae on all the segments including the 1st . . . . . 3.
3. Abdomen short and cylindrical as in *polyodon*; 1st segment dark with denticulate markings not developed; frons in male fully of eye width, with the frontal setae on each side in an irregular double row; profrons produced more than in the next species (female genitalia not known) (non-British) . . . . . **dumosa,** Fall., ♂.
   Abdomen lengthened, and somewhat flattened, the 1st segment being longer than the 2nd; the denticulate markings lengthened and clearly defined and fully developed also on the 1st segment; male frons slightly under eye width, the frontal setae in a single regular row; the female has conspicuous genitalia projecting backwards as a tapered spike; alulae large; ventral plates long and narrow . . **ungulans,** Pand.

A genus of rare flies with very characteristic head; the profrons prominent, with short antennae inserted high above the eye middle; the lower part of the interfacialia strongly constricted, the vibrissaria closely approximated high above the peristomal edge; the eyes are small, and the genae and lateralia wide, the genae being well furnished with bristly hairs. *Griseola*, Fall. (= *viatica*, Mg.), was first taken in this country at Porthcawl, S. Wales, by Col. Yerbury on 12.vi.03, and recorded by him in *Trans. Ent. Soc. London*, 1906, p. 392. I possess a single female taken at the same place by Mr. H. W. Andrews, and have also seen a male taken by Mr. A. H. Hamm at Oxshott, Surrey, and another taken by Mr. F. Jenkinson at N. Walsham. The other species have been mixed in collections and records regarding them are very unreliable. Of *polyodon* I possess a male from Logie (F. Jenkinson) and a female from West Runton, and have seen others from King's Lynn (E. A. Atmore) and Tubney (J. Collins), etc. *Ungulans*, Pand., has been taken by Mr. Jenkinson at Cambridge on various occasions, and I have seen several specimens, which are now in the Cambridge Museum; I have also seen from the same collection a pair "Bred from elm logs, Grantchurch, about May 10–15, 1920, with *Crabro cavifrons*, Thoms (C. Warburton)," and two females from Lyndhurst bred by Dr. Sharp. Various records exist under the name *agrestis*, but it is uncertain to which of the species they really apply. *Dumosa*, Fall., seems most likely to be the species intended by Stein and other continental writers by *agrestis*, but so far I have not seen a British *dumosa*, though it may occur yet.

CALLIPHORINAE.

This subfamily forms the most distinct group within the great family of the TACHINIDAE, and includes some of the best-known and most abundant

and assertive of those Diptera to which the term fly most peculiarly belongs; and yet although some of the species, such for example as *Calliphora vomitoria*, L., the common blowfly, are known to everyone, the group as a whole is even less understood than the rest of the family. As some of the species play very important parts in the economy of nature as it affects man, especially in regard to sanitation and health, better knowledge is most essential, and an exhaustive study of the CALLIPHORINAE of the world would be a most desirable achievement.

The members of the subfamily can usually be distinguished at once by the greatly reduced chaetotaxy, the abdomen generally being almost without bristles; by the large 1st sternite or ventral plate, the edges of which overlie the lower edges of the corresponding tergites or dorsal plates; by the long ciliation of the arista, which, however, is less long in some genera such as *Onesia*; and finally by the trifling but characteristic detail of the placing of the thoracic setae, as described in the table.

At one time these flies, together with *Musca domestica*, L., and some allied genera, *Pyrellia*, *Morellia*, etc., were associated in one family or sub-family, for which the name of MUSCIDAE was specially reserved; but Girschner's investigations revealed the fact that the group was by no means homogeneous, and indeed fell into two nearly equal parts, one of which he removed altogether to the other great section of the Calyptratae, the ANTHOMYIIDAE. At first so radical a change seemed the greatest argument against the Girschnerian system, but it is now, I think, realised that the differences between the two groups are very deep seated, confirmation appearing in a number of details, so that now it has become obvious that the striking similarity between some of the genera in the two groups, notably *Lucilia* and *Pyrellia*, marks no relationship and must be due to some quite different cause, which I suggest may be a form of Müllerian mimicry.

Apart from the failure of the hypopleural bristles in all those genera removed to the ANTHOMYIIDAE, the 4th longitudinal vein is almost always gently curved forwards, whilst in the CALLIPHORINAE it is more or less abruptly bent; and there are differences in the chaetotaxy and in the ventral plates, the latter especially being quite characteristic in the Anthomyiid genera, the tergites and sternites being separated and surrounded by a distinct stretch of membrane with no sign of the Calliphorine character of the 1st sternite overlying the edges of the tergites.

126. POLLENIA, R.-D.*

1. Abdomen glossy and shining with no tomentum . . . . . **vespillo,** F.
   Abdomen not glossy and shining but more or less covered with tomentum 2.
2. Abdomen olivaceous in colour with the tomentum varying much according to point of view, and appearing distinctly tessellated; thorax with four slight stripes . . . . . **rudis,** F.
   Abdomen bluish; the tomentum less variable and more uniform; thorax with three stripes . . . . . **vagabunda,** Mg.

The species of this genus can be recognised easily on account of the golden hair-like scales scattered about the thorax; these seem to be found in no other flies. The vibrissaria are rather high above the epistomal edge; the genae wide and hairy; the thoracic and scutellar setae strong and well developed, with three D.C.

Vespillo and *rudis* are two of the commonest of our flies, practically

* For STOMATORRHINA, Rond., see appendix (B).

ubiquitous and usually abundant. *Vagabunda* has not been known as a British insect till now, but recently Prof. Carr sent me two females that had been taken at the Birklands, Sherwood Forest, which I think belong without doubt to this species. It is distinctly bluish in colour like *Calliphora vomitoria*, L., in that respect, and the difference in the thoracic stripes seems definite; the frons is narrower than in *rudis* with which alone it could be compared, and the antennae have the 3rd joint less than twice the length of the second. The head too is blacker, with little trace of the ruddy colouring usual in *rudis*.

Various other names have appeared in British lists, but I believe they have all been based upon varieties of the two common species.

127. PHORMIA, R.-D.

1. Thoracic chaetotaxy ill developed; four D.C., but the front ones very small and even indistinguishable at times; the acrostichals very weak and scarcely distinguishable before the suture . . . . . 2.

   Thoracic chaetotaxy strongly developed; the full series of dorso-centrals and of acrostichals strong and distinct (male bluish in colour, female greenish; frons fully one and a half times as wide as the 3rd joint of antennae; palpi yellow but dark-tipped; alulae pale yellowish; upper part of genae well furnished with short hairs which extend almost down to the mediana) . . . . . **sordida,** Zett., Stein (**azurea,** auct.).

2. Frons very narrow, only about half the width of 3rd antennal joint; female frons about eye width; metallic green species resembling those of the genus *Lucilia* (palpi all yellow; genal hairs few and restricted to the upper part only, so that one might say genae bare; alulae whitish). **regina,** Mg.

   Frons wider, wider than in *sordida*, equal to about two and a half times the antennal width; female frons about one-quarter wider than one eye; metallic-blue shining species (palpi all yellow; alulae smoky; genal hairs as in *regina*, but perhaps a little more extended). **caerulea,** R.-D. (**groenlandica,** Zett.).

I have followed Stein in the nomenclature of this genus. Two of the species, *sordida*, Zett., and *caerulea*, R.-D., are amongst our commonest flies and are sometimes abundant. *Regina* appears to be rare; Mr. J. E. Collin has a pair sent years ago to Mr. Verrall from Dublin by Mr. A. W. Foote, and Mr. A. H. Hamm has reported its capture. It may not be so rare, but very little attention has been paid to the "bluebottles" by collectors.

128. LUCILIA, R.-D.

1. Species with only two pairs of postsutural acrostichal setae. (All these species have the basicosta dark) . . . . . 2.

   Species with three pairs of acrostichals behind the suture . . . . . 5.

2. Males have very narrow frons, at the narrowest part being less than the width of the 3rd antennal joint; the frontalia reduced to a fine line and sometimes nearly if not quite disappearing at the narrowest part . . 3.

   Males with frons also narrow, but a little wider than 3rd antennal joint; the frontalia at the narrowest point distinct, being even there at least as wide as the reduced fronto-orbits . . . . . 4.

3. Hypopygium altogether large. When seen in profile the side claspers of the genitalia (= the paralobes) appear pointed, tapered and slightly curved sicklewise; in the middle forceps (mesolobe) the thin apical portion curves inwards and then somewhat abruptly upwards to the thicker basal portion; no conspicuous hairs on the inner posterior edge of the last genital segment . . . . . **caesar,** L.

Hypopygium as a whole small; side claspers seen in profile show wide rounded ends, sides practically parallel and are straight, not curved; middle forceps with upper margin appearing level, with no inward curve; long conspicuous hairs on inner posterior margin of last genital segment . . . . . **ampullacea,** Villen. (**flavipennis,** Kramer).

4. Abdomen with 2nd visible segment bearing strong hind-marginal macrochaetae; palpi black; side claspers (paralobes) of the genitalia, as seen in profile, straight, thick and with wide blunt ends . **bufonivora,** Mon.

No setae on 2nd abdominal segment (in this resembling *caesar* and *flavipennis*); palpi yellow; seen in profile the side claspers of the genitalia appear thin and tapered, and clearly hooked at the point (this species bears distinct whitish tomentum on the abdomen, and this helps to distinguish it from any other in the genus) . **illustris,** Mg. (**simulatrix,** Pand.).

5. Abdomen with strong marginal macrochaetae on the 2nd visible segment; palpi black; frons about one-quarter of eye width; genitalia with centre clasper (mesolobe) long, thin, tapered, pointed and straight; basicosta dark . . . . . **silvarum,** Mg.

Abdomen with no macrochaetae on the edge of the 2nd segment (there are often some long strong hairs which, however, are not thick enough to be called macrochaetae); basicosta yellow . . . . . 6.

6. Frons in male with the frontalia about the same width as the fronto-orbits; mid-tibiae armed with two strong antero-dorsal bristles; genitalia with central clasper (the mesolobe) as seen from below thin, and narrowed in the middle part; inner hind margin of last genital segment bearing long and conspicuous hairs (as in *ampullacea*, Villen.). **richardsi,** Collin.

Frons in male with the frontalia nearly twice as wide as one of the fronto-orbits; mid-tibiae with only one antero-dorsal bristle; genitalia with the mesolobe thin, wedge-shaped, regularly tapered and keeled. **sericata,** Mg.

The females of the above cannot be separated with certainty. Those with only two pairs of postsutural acrostichals and no hind-marginal setae on the 2nd segment belong to either *caesar*, L., *illustris*, Mg., or *ampullacea*, Villen.; possibly *illustris* has a wider frons than the others. *Bufonivora*, Mon., can perhaps be recognised through possessing two pairs only of acrostichals with strong marginal setae on the 2nd segment; *silvarum*, Mg., by having three pairs of acrostichals and strong marginal setae. *Sericata*, Mg., and *richardsi*, Collin, are alike in possessing three pairs of acrostichals and no hind-marginal setae; possibly the two bristles on the antero-dorsal edge of the mid-tibiae may enable *richardsi* to be recognised, as it seems to me that this character is equally useful in both sexes.

The species of this genus are common and familiar to most, constituting with those of the genus *Pyrellia* (of the ANTHOMYIIDAE) the well-known greenbottle flies. The best-known and probably most widely distributed is *caesar*, L. This species has, however, two very close allies which have been but little distinguished till now: one, *illustris*, Mg. (= *simulatrix*, Pand.), was first recognised by me as British in 1916, when I saw a pair taken *in cop.* at Cambridge by Mr. F. Jenkinson on 2.ix.1902, and now in the Cambridge Museum; afterwards Mr. H. Britten sent me specimens taken in various localities in the neighbourhood of Manchester. Mr. O. W. Richards, in his recent paper on the genus (*Trans. Ent. Soc. Lond.*, Vol. 74, pp. 255 *et seq.*), expresses the opinion that it is as common as *caesar*, L. The other species, *ampullacea*, Villen., was not known as British until Mr. Richards recorded it in the above-mentioned

paper. Mr. A. H. Hamm took two males at Greenham Common, Newbury, Berks, in June 1916, and others since in Oxfordshire, where Mr. J. Collins also found it in Waterperry Wood; Mr. J. E. Collin in a supplement to Mr. Richards' paper also records a single male taken at Lyndhurst on May 29, 1897, and I have since taken two males and one female in Wyre Forest on 4.ix.27.

Stein (24), Lundbeck (28) and Richards (*loc. cit.*) all use Kramer's name *flavipennis*, but Séguy in "Diptera," Vol. II, p. 94, calls attention to the use by Macquart in 1843 of the same name for a species from Ceylon, etc., and proposes the new name *krameri* to take its place. He appears to have overlooked *ampullacea*, Villeneuve, which has priority.

Bufonivora,* Moniez, seems equally rare; I have had a single male, taken at West Hide in Herefordshire on 30.v.99, in my collection so named for some years, but had known of no other until Mr. Richards' (*loc. cit.*) record of a specimen in Mr. J. E. Collin's collection, taken at Three Bridges (Sussex), 17.vi.92, and four males, taken by himself at Windover, Bucks, 22.vi.26.

Silvarum, Mg., is well known, but I think not really common.

Sericata, Mg., and *richardsi*, Collin, had been mixed in most collections until the publication of Richards' paper, when the one species was described as new and given the name of *richardsi* by Mr. Collin. I had had them separated in my own collection for some years, but without any distinctive names, merely calling them *sericata*, A. & B. The species which Mr. Richards and Mr. Collin regard as the true *sericata*, Mg., seems to be the rarer of the two in this country; most of mine came from St. Ives, Cornwall, odd specimens, however, from West Malvern, and females which I regard as this species, from West Runton, Norfolk; Mr. Richards only records it from Lye Hill, Oxford (A. H. Hamm), Barton Mill, Suffolk (A. H. Hamm), and Oxford (J. Collins). On the other hand, the new species *richardsi* seems to be a common one here, and I have it from many localities.

There are other species of the genus known on the Continent and they may occur here. The genital characters will require very close observation to enable them to be detected.

129. **Calliphora**, R.-D.

1. Frons in the males very narrow, at the narrowest point the frontalia practically disappears . . . . . 2.
   Frons in males wider, the frontalia at the narrowest part at least as wide as each fronto-orbit; buccae more or less rufous, generally extensively so, but the numerous strong hairs on them all black . . **erythrocephala,** Mg.
2. Buccae dark (the mediana, however, conspicuously reddish), but the hairs mainly rufous . . . . . **vomitoria,** L.
   Buccae also dark (the mediana still remaining reddish), but the hairs also all black . . . . . **germanorum,** Villen.

These are the all too common bluebottles or blowflies. They have not received the close attention they deserve, so that other species may be mixed with the two common ones *vomitoria*, L., and *erythrocephala*, Mg., which are ubiquitous. A single *germanorum* was taken by me at Aviemore, 23.vi.1919, by chance; it was not recognised at the time, so that probably others could have been taken easily. The genital claspers are quite distinct from those of the other species, thus confirming the value of the more superficial characters. Seen in profile the side claspers (paralobes) in *germanorum* are long, tapered,

* Mr. G. Fox Wilson in the *Gardeners' Chronicle* of July 30, 1927, published an account of this species, from which it appears that it is a serious pest to toads at Wisley and elsewhere, so that evidently the species is common enough, indeed too common.

thin and straight; in *erythrocephala* they are shorter, blunt-ended and almost parallel-sided; whilst in *vomitoria* they are long and very thin and curved, with the end rounded rather than pointed. I have since seen two females, taken at Logie by Mr. F. Jenkinson, and Mr. J. E. Collin has a female, taken by Col. Yerbury at Nethy Bridge.

130. Onesia, R.-D.

1. Male genitalia with the side claspers (paralobes) as seen in profile straight and tapered to a comparatively sharp point; middle clasper or mesolobe as seen from below narrow and tapered regularly from base to tip, and convex . . . . . **aculeata,** Pand.
2. Male genitalia with paralobes thick and blunt-ended, almost parallel-sided, and nearly straight; mesolobe seen from below narrow and tapered as in *aculeata*, but concave or grooved . . . . . **agilis,** Mg.
3. Male genitalia with paralobes thick and blunt as in *agilis*, but strongly bent; mesolobe seen from below wide at the base, and abruptly narrowed before the middle, ending thin and aculeate . . **biseta,** Villen.

These three species represent what was formerly called *sepulchralis*, Mg., the true *sepulchralis*, Mg., so far as I know, not having been discovered in this country at present. Our three species seem to be absolutely indistinguishable excepting from the male genitalia, and the differences in these are not striking, although they seem so constant that one must regard the species as distinct. Possibly they may prove to be biological species, and when more is known about their life-histories it may be possible to understand the meaning of distinctions with such slight differences. The females, of course, in such circumstances cannot be separated, excepting that I fancied that the hind margin of the 1st visible abdominal segment in *aculeata* was thicker than in *agilis*.

Dr. Villeneuve having examined Meigen's type of *sepulchralis* tells me that it is identical with *subapennina*, Rond., and *retrocurva*, Pand. In this species the side claspers in the male genitalia are curiously bent in a loop, so that as seen in profile the paralobe and mesolobe enclose an open space. I fancy it is more of a southern insect, but it may still prove to be British.

At present I have but one British *biseta*, from Torquay, but the other two species are both common, *agilis* perhaps the more abundant of the two. The species of this genus can be readily recognised by the short ciliation at the base only of the arista, as in the species of the genus *Sarcophaga*; the very hairy and wide genae; the conspicuous hairs on the disc of the alulae, and dull metallic green coloration of the abdomen.

131. Melinda, R.-D.

1. Praesutural intra-alar setae present. Male frons very narrow, at its narrowest point the frontalia reduced to a fine line; male abdominal segments two and three largely shining, owing to slight development of the tomentum; palpi somewhat yellowish; male genitalia seen from the side show narrow paralobes, nearly parallel-sided, and seen from below the mesolobe is abruptly widened in the basal half.
anthracina, Mg. (= **gentilis,** Stein).
2. Praesutural intra-alar missing. Male frons wider, the frontalia at the narrowest point being nearly equal to half the total width; male abdomen with 2nd and 3rd visible segments not shining but covered by the whitish tomentum; usually a smaller species. Genitalia seen in side view show paralobes greatly widened so as to form a widish oval; mesolobe seen from below narrow and tapered throughout; palpi dark.
caerulea, Mg. (= **cognata,** plur. auct.).

Two common species which seem to have been confused a great deal, although the characters given above are clear and good. In the female sex unfortunately it is again difficult to separate them, but the presence or absence of the praesutural intra-alar bristle will probably serve; there is also a difference in the degree of pruinosity on the abdomen in this sex also, but curiously enough it appears to be reversed compared with the males, for the female of *anthracina* seems to have more tomentum and in the female of *caerulea* the tomentum tends to fail and leave the abdomen shining. *Anthracina* still remains the larger species.

With some doubt and for the sake of uniformity I have followed Stein in the use of the above names. Meigen's descriptions are not sufficient, and I do not know if his types have been examined, but Schiner, who was the first to distinguish clearly between the species, certainly reversed the names, using *gentilis* for the smaller species with much tomentum and *cognata* for the larger and shinier one. The synonymy, *anthracina*, Mg. = *gentilis*, Stein, I owe to Dr. Villeneuve.

I have no hesitation in regarding this genus as distinct from *Onesia*, the bare alulae and much smaller genitalia, apart from appearance and the blue coloration, being sufficient to distinguish a genus as clearly characterised as any in the CALLIPHORINAE.

132. CYNOMYIA, R.-D.

A single species, **mortuorum,** L., rather a large handsome and very distinct Calliphorid; with its bright metallic blue thorax and abdomen, and the head mainly brilliant orange-yellow, it is readily recognised. It is uncommon, at least in the south, although I possess a specimen taken in my own garden near Birmingham, and have seen others from Wicken and the Forest of Dean. In the north, however, it appears to occur much more freely, and I have myself taken it at Aviemore, and Nethy Bridge, and have seen others from various localities, Logie (F. Jenkinson), Cromarty, Aberdeen, Inverness (Allard), etc.

133. ACROPHAGA, B. & B.

One species again, **alpina,** Zett., a similar insect to the last, but altogether smaller and less brilliant. There is less yellow about the head, the buccae, frontorbita and part of the antennae being darkened, and the genitalia are not quite so large and conspicuous, but still distinctive. It seems uncommon, but like *Cynomyia* is probably a northern insect. My few specimens came from Aviemore, Grantown, Rhayader, and Ran Dan Woods, Worcestershire; and I have seen others in the Cambridge Museum from Logie and The Aird (F. Jenkinson).

PHASIINAE.

134. GYMNOSOMA, Mg.

This genus begins the PHASIINAE, a group of rare, somewhat specialised flies, unlike the normal TACHINIDAE. Of this genus there is only one British species, **rotundatum,** L., a very distinct insect, rotund in shape as indicated by the specific name, practically free from bristles, and of a conspicuous golden yellow coloration with black markings. It is a well-known and fairly common species on the Continent, but is rare in this country and I have never met with it myself, but have specimens taken at Glengariff, Ireland, by Mr. H. W. Andrews, who apparently met with it there in some numbers. In the British

Museum are specimens from Hastings (Rev. E. N. Bloomfield), and Mr. J. E. Collin has three pairs in the Verrall collection taken at Abbotts Wood.

135. FRERAEA, R.-D.

One species, **albipennis,** Zett. A remarkable and distinct little fly, with very slight chaetal development, the abdomen, thorax, etc., practically all shining black; very short antennae; profrons distinct, but the genae and buccae narrow, and the face sloping away without any distinct angular development at the epistoma, so that head seems produced to a point at the antennae; 4th vein very gently upcurved towards the 3rd. The female has a remarkably developed 5th (visible) abdominal segment, very long and incurved under the abdomen with a claw-like process at the end; the male also has the end of the abdomen somewhat incurved. It is a very rare little species; the first known British one was a male taken by Mr. Claude Morley at Brandon on June 22, 1914, and kindly sent to me for identification by Mr. F. W. Edwards. Since then Mr. J. E. Collin recognised the species in a female taken by Mr. A. E. J. Carter at Pitlochry in 1920, and has taken another female on July 17 of last year (1927) at Tubney near Oxford. I have followed the Katalog in using Desvoidy's name *Freraea* for the genus, and it seems likely that his name **gagatea** may have to be revived for this species.

136. SYNTOMOGASTER, Sch.

1. Abdomen with yellow cross-bands . . . . . **fasciata,** Macq.
2. Abdomen with no yellow markings . . . . . **exigua,** Mg.

Two small rare and inconspicuous species, possibly merely overlooked and not so rare as they seem. *Exigua* (= *vidua*, Egger) I have from West Malvern and Stoke Wood (Dr. Wood), both in Herefordshire, and have seen others from the New Forest (Dr. Sharp), Lymington (F. Jenkinson), Leith Hill, Surrey (Rev. A. Thornley), and Heathfield (J. E. Collin). Mr. Verrall also recorded it from Stoke and Hough Woods, Herefordshire, in which county it appears to be comparatively frequent. Of *fasciata* I have examined only one female from the New Forest (June 1902, Dr. Sharp; now in the Cambridge Museum); there is another so named in the British Museum from Tarrington (Yerbury); Dr. Wood, I believe, also took it in Stoke Wood, Herefordshire; Mr. J. E. Collin has one from Scotland, Aviemore, and it was recorded by Verrall in the *E.M.M.* (1911, p. 79; and 1912, p. 192) from Lyndhurst, and King's Lynn (Atmore). They are not strongly characterised; the vibrissaria are well above the peristomal edge, but the interfacialia is rather flat and not much produced between the vibrissaria. Genae bare; frons in male very narrow; macrochaetae numerous and long, but thin and hair-like; discals and marginals on the abdomen; first posterior wing-cell closed and short-stalked; conspicuous bands of silvery tomentum on the abdomen.

137. CINOCHIRA, Zett.

One species, **atra,** Zett., a very small and inconspicuous black species very unlike a typical Tachinid. The 4th longitudinal wing-vein with no definite bending and only slightly curved forwards, so that it suggests a small Anthomyiid. Col. Yerbury and Mr. J. E. Collin found it at Butley Thicks near Woodbridge in Suffolk on July 10, 1908, when it appears to have occurred in some numbers; Mr. J. E. Collin also has a male from St. Germains, Cornwall, and another from Cambridge (F. Jenkinson), and Prof. Poulton

found one on a window in the Isle of Wight; there were also specimens in Dr. J. H. Wood's collection from several Herefordshire localities; otherwise it seems to have escaped notice, but may easily prove to be widely distributed.

138. WEBERIA, R.-D.

1. Larger species, nearly 7 mm. long, with dull thorax, and no praesutural acrostichals; possessing a number of conspicuous bristles on the hind tibiae at the tip; frons about three-fifths of eye width . . **thoracica,** Mg.
2. Smaller species, only about 5 to 6 mm. long, with shining thorax; possessing praesutural acrostichals, but no unusual bristles on the hind tibiae; frons narrower, about half eye width . . **curvicauda,** Mg. nec Zett.

Narrow-bodied black species with the abdomen curved downwards and inwards; the underside of the head long and straight, with produced epistoma, and vibrissaria almost on the peristomal edge; narrow genae and lateralia; chaetotaxy well developed, the macrochaetae strong, but no abdominal discals; 1st posterior wing-cell open. Both species seem rare; *thoracica* was taken in Herefordshire by Dr. J. H. Wood, and I possess two of his specimens from Mains Wood; in the British Museum are four specimens so named, not examined by me, taken at Guestling, Hastings, by the Rev. E. N. Bloomfield, and I know of no other British specimens. *Curvicauda* seems to be commoner, and I possess it from Farningham (H. W. Andrews), Cambridge (F. Jenkinson and A. Allard), and Thames Marshes (H. W. Andrews); and have examined others from Felixstowe (A. Piffard, nine specimens in the British Museum), and Shelford, Cambridge, Swaffham, Abington, etc. (all taken by F. Jenkinson, and in the Cambridge Museum). There is also a further series so named in the British Museum taken by Col. Yerbury at Gravesend.

On the Continent are some very closely allied and little-known species, so that individuals of this genus should be carefully examined.

139. XYSTA, Mg.

Cana, Mg. A rare and little-known species which I have never met with, Major E. E. Austen, however, recorded (*E.M.M.*, 1898, pp. 39–40) the capture by Mr. Claude Morley of two specimens at Ipswich, one in May, 1894, the other on May 23, 1896, also one from Felden, Herts, taken by Mr. A. Piffard on May 14, 1894. Mr. Piffard afterwards took another on May 20, 1899. It should be easily recognised, as the typically Phasiine face with its projecting lower portion and high vibrissaria, in combination with the very narrow frons and unstalked posterior cell form a good combination of characters. The chaetotaxy is reduced, there are no or only very small bristles on the first two abdominal segments and only marginals on the others, and those on the thorax are short; only one pair praescutellary acrostichals present, and three D.C. There are several species of the genus known on the Continent, but *cana* is distinguished by thick ashy-grey tomentum on the abdomen, whitish alulae, and absence of distinct vertical bristles.

(Mr. Collin has since taken a very fine male at Kirtling near to Newmarket on 31.v.25, which I have had the pleasure of examining.)

140. CLYTIOMYIA, Rond.

Continua, Panz., has been in the British list for some time, but I know almost nothing of it as a British insect. It is a distinct little species, mostly yellowish in colour, with the frons wide and conspicuously shining with an

almost metallic golden yellow. The abdomen bears more fully developed bristles than is usual in this group of genera; the face is typically Phasiine, with prominent domed lower portion and the vibrissaria well above the peristoma; there is an extra abdominal segment, the 6th, seen from above (making five clearly visible).

141. Allophora, R.-D.

One species, **hemiptera,** F., a conspicuous and well-known insect, which is very variable and sexually dimorphic. The male usually has greatly widened wings with brown and yellow markings and the abdomen largely yellow at the sides, but is sometimes like the female with normal-sized, colourless wings and very little yellow on the abdomen. The chaetotaxy is greatly reduced, the abdomen practically having no macrochaetae; the 6th abdominal segment is visible above as in the last genus; the 1st posterior wing-cell is stalked; the frons is rather narrow, but the face very wide and becoming so abruptly. It is not generally common but I have seen it occurring in some numbers in the New Forest, and also at Lynton and Barmouth, and have specimens from Stradbally, Ireland (H. W. Andrews). Other records are Tarrington, Herefordshire; Ivybridge, Devon (both Col. Yerbury); Long Sutton, Hants (J. E. Collin), etc.

142. Hyalomyia, R.-D.

One species, **obesa,** F., allied to the last, and similar, but much smaller. In this also the males vary considerably, some possessing enlarged wings with markings, but not to the striking and conspicuous extent of *hemiptera*. I have scarcely met with it in this country, but think this may be mere chance, as I fancy it will prove to be at least as common as *hemiptera*. My only specimen is from Logie (F. Jenkinson), but I have examined others from Stokenchurch, and Holne (British Museum, Yerbury) and Farncombe, Surrey (Rev. A. Thornley); and there is a good series from Felden, Herts (A. Piffard), in the British Museum.

143. Parallophora, Girsch.

Pusilla, Mg. The smallest of this group of species, similar to the last but decidedly smaller, and apparently the males have none of the unusual development of the wings of the last two species. It is the commonest of the three, and I have it from Wyre Forest, Chippenham, Chalford, Glos., and West Hide, Herefordshire, and have seen it from a number of other localities: Wolmer Forest, Stokenchurch, Gravesend, etc. (all Yerbury); New Forest (Dr. Sharp); Cambridge (F. Jenkinson), etc.

V. Literature cited.

There is no attempt here to give a full list of even the more important works dealing with this family; these are merely references to some of the publications specially mentioned in previous pages.

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VI. Appendix (A).

Mr. J. E. Collin expressed a desire that I should attempt to collate the species of my list with those in Verrall's List of British Diptera published in 1901, and I have made the following notes accordingly. I have taken the genera as and in the order in which they occur in Verrall's List, have omitted entirely any reference to

species which are under the same name in both, and quoting the Verrallian name first, have then given what information I can about it.

Meigenia, Dsv., *egens*, Egg. = *incana*, Fall.; I have not met with it; *bisignata*, Mg., and *floralis*, Mg., are now regarded as one species = *mutabilis*, Fall., and *dorsalis*, Mg., and *vernalis*, Dsv., as synonyms; *majuscula*, Rond., see subgenus *Mystacella*, Wulp.

Ceromasia, Rond., *machairopsis*, B. & B. = *Lydella nigripes*, Fall.; *agilis*, Mg., is a synonym, but *angelicae*, Mg., is a distinct species which I have not seen; *florum*, Macq., is probably *Lydella ferruginea*, Mg.; true *florum* (Macq.) Rond., is not likely to be British; the synonymy is uncertain; *juvenilis*, Rond., I do not know, it appears to be a distinct species; *senilis*, Mg., see genus *Paraphorocera*, B. & B.; *brevipennis*, Mg., is referred to *Lydella nigripes*, Fall., in the "Katalog," with a query; *parva* (Macq.?), is sunk as a synonym of *Meigenia mutabilis*, Fall.; *stabulans*, Mg., see genus *Lydella*; *spectabilis*, Mg. = *Lydella albisquama*, Zett.

Exorista, Mg. This old genus has been much divided: *vetula*, Mg., see genus *Phryno*, R.-D.; *cheloniae*, Rond., *biserialis*, Macq., *flavicans*, Rond., *jucunda*, Mg., and *lucorum*, Mg., all refer to species of *Carcelia*, but the synonymy of that genus is so involved that it is impossible to be certain which, and I have no confidence in my own determinations; *agnata*, Rond., *affinis*, Mg., and *fimbriata*, Mg., are true Exoristas; *notabilis*, Mg. = *Nemorilla floralis*, Fall.; *mutabilis*, Fall., is now used for *Meigenia floralis*, Mg., etc., and I do not know what Verrall's *mutabilis* can have been; *perturbans*, Zett., is now regarded as a species of *Phryno*, R.-D., and I have not met with it; *ruficauda*, Zett., see genus *Eversmannia*, R.-D.; *noctuicida*, Rond., appears to be a good species of *Exorista* which I do not know.

Epicampocera, Macq., *ambulans*, Mg. = *Epicampocera* (*Megalochaeta*) *conspersa*, Mg.

Blepharidea, Rond. = *Phryxe*, R.-D.

Myxexorista, B. & B. = *Zenillia*, R.-D.; the three names *fauna*, Mg., *macrops*, B. & B., and *libatrix*, Mg., probably all stand for but one species, that now called *libatrix*, Mg.

Frontina, Mg., *nigricans*, Egg. see genus, *Prosopaea*, Rond.; I have not met with it; *laeta*, W., the true representative of the genus *Frontina*, is not likely to prove British; *fugax*, Rond., apparently = *Prosopodes fugax*, Rond. = a variety of *Ptychomyia selecta*, Mg.

Campylochaeta, Rond., *obscura*, Fall. = *praecox*, Mg.

Phorocera, Dsv., *serriventris*, Rond. = *Compsilura concinnata*, Mg.; *cilipeda*, Rond. = *Pales pavida*, Mg.; *pumicata*, Mg., see genus *Pales*, R.-D.; *gracilis*, Egg. = *Staurochaeta albocingulata*, Fall.

Bothria, Rond., *assimilis*, Fall., and *caesifrons*, Macq., see genus *Phorocera*, R.-D.; *segregata*, B. & B. nec Rond. = *Parasetigena silvestris*, R.-D.; *segregata*, Rond., see genus *Tricholyga*, Rond.; *frontosa*, Mg. = *Bothria obliquata*, Fall., a species I have not met with.

Blepharipoda, Rond., *scutellata*, Dsv., see genus *Sturmia*, R.-D.; I have not seen a British specimen; *atropivora*, Rond., see genus *Sturmia*, subgenus *Argyrophylax*, B. & B., another species of which I have not seen a British one.

Sisyropa, B. & B. = genus *Carcelia*, R.-D., in toto; all the names represent species in the genus, but as already remarked the synonymy is so involved as to make it impossible to decide to which to refer them.

Chaetolyga, Rond. = *Winthemia*, R.-D.; *analis*, Macq., is a synonym of *quadripustulata*, F.; *apicalis*, Mg., is a good species of which I have not seen British specimens, but which may well occur here; *nigrithorax*, Egger, see *variegata*, Mg.

Tachina, L. With the exception of *praepotens*, Mg., which is treated as a synonym of *larvarum*, L., all the species of *Tachina* in Verrall's List are given specific rank in the "Katalog"; almost certainly, however, they represent, at least in

this country, only the three or four species of my tables; *grandis*, Egg., may perhaps be *fasciata*, Fall.; *erucarum*, Rond., is probably but a form of *rustica*, Mg.; *noctuarum*, Rond., and *latifrons*, Rond., may both represent forms of *larvarum*, L., and *nigricans*, Egger, is a small dark form of *rustica*, Mg.

Gonia, Mg., *trifaria*, Zett., is now referred to *capitata*, Deg., as a synonym.

Thelymorpha, B. & B., *vertiginosa*, Fall. = *Histochaeta marmorata*, F.

Monochaeta, B. & B.; the species is now called *albicans*, Fall., and *leucophaea*, Mg., is sunk as a synonym.

Aporomyia, Rond. = *Lypha*, R.-D.

Somolia rebaptizata, Rond. = *Lydina aenea*, Mg.

Micronychia, B. & B. = *Eversmannia*, Zett.

Mintho, Dsv. There are two well-known species on the Continent with a hopelessly mixed synonymy; I have only seen one British species, which I have called *rufiventris*, Fall. var. *lacera*, Rond.; both the names, *praeceps* and *compressa*, have been used for both species.

Melanota, Rond. = *Phyllomyia*, R.-D.

Macquartia, Dsv.; *tenebricosa*, Mg., *nitida*, Zett., *affinis*, Sch., and *caelebs*, Rond., all probably represent what I have called *chalconota*, Mg., *sens. lat.*; the species, however, is probably a mixture, and one or more of the above names may represent good species; *spinicincta*, Meade = *praefica*, Mg.; *ciliaris*, Zett., is treated as a good species in the "Katalog," but I do not know it.

Macroprosopa atrata, Mg., I have never seen.

Loewia, Egg., *setibarba*, Egg., and *brevifrons*, Rond., probably represent two good species; see my notes.

Ptilops, Rond. = *Minella*, R.-D.

Anthracomyia, Rdi, *nana*, Mg., see genus *Morinia*, R.-D.; *anthracina*, Mg. = *Morinia* (*Medoria*) *digramma*, Mg.

Degeeria, Mg., *ornata*, Mg., is sunk as synonym to *collaris*, Fall.; *medorina*, Sch., and *pulchella*, Mg., become synonyms of *luctuosa*, Mg.; *pygmaea*, Macq., and *grandicornis*, Zett., are apparently at present unrecognised species, and I do not know them.

Thelaira, Dsv.; only one species, *nigripes*, F.; *leucozona*, Panz., is a synonym.

Demoticus, Macq., *longirostris*, Mg., see genus *Aphria*, R.-D.; *frontatus*, Boh., and *spretus*, Mg. = *Bithia spreta*, Mg., with *frontata*, Boh., as synonym.

Myiobia, Dsv., *aurea*, Fall., see genus *Leskia*, R.-D.; a rare species of which I do not know a British specimen; the other four names doubtless stand for the species dealt with in my tables, but the synonymy is very involved.

Olivieria lateralis, F. = *Eriothrix rufomaculatus*, Deg.

Ocyptera, Ltr., *cylindrica*, F. = *boscii*, R.-D.; see my notes, where I suggest that British *cylindrica*, F., are only colour variations of *brassicaria*, F.

Ocypterula, Rond., *pusilla*, Mg., probably recorded in error, so-called specimens being most likely *Ocyptera interrupta*, Mg.

Micropalpus, Macq., *comptus* = *comta*, Fall.; *pictus*, Mg., now *haemorrhoidalis*, Fall.

Erigone, Dsv. = *Ernestia*, R.-D. *Strenua*, Mg., is a synonym of (*Panzeria*) *rudis*, Fall.; *vagans*, Mg., perhaps another; *appendiculata*, Macq. = (*Appendicia*) *truncata*, Zett.; *intermedia*, Zett. = *conjugata*, Zett.; *setosa*, Macq., is referred to *vivida*, Zett., by the authors of the "Katalog."

Fabricia, Dsv. = *Fabriciella*, Bezzi.

Peleteria, Dsv., *tessellata*, F. = *nigricornis*, Mg.

Plagia, Mg.; for our three species, see genus *Voria*, R.-D. *sens. lat.*; *ruralis*, Fall., and *curvinervis*, Zett., see subgen. *Voria*; *trepida*, Mg., see subgen. *Paraplagia*, B. & B.

Phorichaeta, Rond. = *Wagneria*, R.-D. *sens. lat.*; *lugens*, Mg. = *costata*, Fall.; *tricincta*, Rond. = *lentis*, Mg. I have not yet recognised *costata*, Fall., but it will probably prove to be British.

Discochaeta muscaria, Fall. = *Microvibrissina muscaria,* Fall.; apparently *cognata,* Schin. = *Erythrocera evonymellae,* Ratzb.

Urophylla, B. & B., *blanda,* Fall., and *seria,* Mg., see genus *Trichoparia,* B. & B.

Roeselia, Dsv. = *Rhacodineura,* Rond.; *antiqua* is Meigen's species; *atra,* Dsv., cannot be recognised.

Stauferia, B. & B., *procera,* Mg., unrecognised; *procera,* Mg., is referred in "Katalog" to *Phyllomyia volvulus,* F.; *procera,* Rond., to *Hypostena,* Mg., now *Apatelia,* Stein.

Thryptocera, Macq.; most of the species are now placed in the genus *Actia,* R.-D., subgen. *Actia,* to which *pilipennis,* Mg., *crassicornis,* Mg., and *bicolor,* Mg., belong; *latifrons,* Mg. = *versicolor,* Fall., is placed in subgen. *Thryptocera*: *minutissima,* Zett., I have not recognised, but have reason to believe that specimens so named were really *Craspedothrix zonella,* Zett.

Hypostena, Mg., *procera,* Mg.; see genus *Apatelia,* Stein.

Siphona, Mg. = *Bucentes,* Latr.

Cercomyia, B. & B. = *Weberia,* R.-D.

Psalida, Rond. = *Leucostoma,* Mg. I have not seen a British *simplex,* Fall.

Phasia rothi, Zett. = *Xysta cana,* Mg.

Alophora, Dsv. recte *Allophora,* divided into subgenera *Allophora* (*hemiptera,* F.), *Hyalomyia* (*obesa,* F.), and *Parallophora* (*pusilla,* Mg.).

Clytia, Dsv. = *Clytiomyia,* Rond. I do not know of a British specimen of any species of the genus.

Trixa, Mg., *grisea,* Mg., and *ferruginea,* Mg., appear to be female and male respectively of *alpina,* Mg., to which both names sink as synonyms. *Scutellata,* Newm., I have not recognised and suspect that it is but a form of *oestroidea,* Dsv.

Fortisia, Rond., see *Loewia,* Egg.

Phyto, Dsv., *nigra,* Dsv., is a synonym of *melanocephala,* Mg.; *parvicornis,* Mg., I have not recognised.

Stevenia maculata, Fall. = *Plesina maculata,* Fall.

Melanophora, Mg., *atra,* Macq., is a synonym of *roralis,* L.

Rhinophora, Dsv., *atramentaria,* Mg., and *melania,* Mg., see *Stevenia,* R.-D., subgen. *Ptilocerina,* Macq.; *simplicissima,* Lw. = *umbratica,* Fall., subgen. *Stevenia.*

Frauenfeldia, Egg., *trilineata,* Mg., is a synonym of *rubricosa,* Mg.

Brachycoma, Rond., *smerinthi,* Meade, is not recognised; *erratica,* Mg., in the "Katalog" is assigned doubtfully to *Dionaea aurifrons,* Mg., a non-British species.

Clista lepida, Mg. = *Rhinophora lepida,* Mg.

Cynomyia, Dsv., *alpina,* see genus *Acrophaga,* B. & B.

Onesia, Dsv., *sepulchralis,* Mg., has not yet proved British; most of the specimens so called are *agilis,* Mg.; *cognata,* Mg., see genus *Melinda,* R.-D.

Sarcophaga, Mg. Verrall's List was published before the work of Kramer, Böttcher, Villeneuve, etc., upon the genitalia of the species of this genus was known, and it is largely impossible to collate identifications, made at that time, with present-day knowledge. Even the "Katalog" is out of date for the same reason, and its synonymy cannot be fully relied upon as a consequence. Whilst some of the names in Verrall's List are absent from mine, yet it is probable that they represent some of the species here recognised, and alternatively it is probable that some of the names which are found in both lists did not really represent the same species. The following notes may, however, be of some service. *Similis,* Meade, has not been recognised, but Pandellé adopted the name for a species which I have not yet found; *albiceps,* Mg., is another species of which I have not seen a British specimen; *atropos,* Mg., is sunk to *carnaria,* L., but *atropos,* Sch. = *incisilobata,* Pand. = *striata,* Mg. (nec F.); *agricola* is not one of Meigen's names, but is Desvoidy's, and Desvoidy's species has been sunk as a synonym of *carnaria,* L.; *agricola,* Meade, however, in the "Katalog" is referred to *hirticrus,* Pand., but this again is a species of which

I have not hitherto seen a British specimen; *laticornis*, Mg., is not recognised; *juvenis*, Rond. = *filia*, Rond.; *adolescens*, Rond., not recognised; *infantula*, Rond. = *dissimilis*, Mg.; *fulvicauda*, Meade, not recognised; *nurus*, Rond. = *haemorrhoidalis*, Mg.; *cruentata*, Mg. = *haemorrhoidalis*, Mg., but *cruentata*, Pand., and perhaps of Verrall's List = *frenata*, Pand., the var. with setose 1st longitudinal vein; *vulnerata*, Sch. = *haemorrhoa*, Mg.; *affinis*, Fall. = *mamillata*, Pand., see genus *Agria*, R.-D. *Erythrura*, Fall., is a species of the genus *Blaesoxypha*, R.-D., a genus which does not seem to occur here at all.

Theria muscaria, Mg. = *Helicobosca distinguenda*, Villen.

Heteronychia chaetoneura, B. & B. = *Sarcophaga dissimilis*, Mg.

Engyops micronyx, B. & B. = *Engyzops pecchiolii*, Rond.

Metopodia, B. & B., see genus *Setulia*, R.-D.

Metopia, Mg., *argyrocephala*, Mg., is sunk as a synonym of *leucocephala*, Rossi, and *amabilis*, Mg., as a synonym of *campestris*, Fall.; *argentata*, Macq., is treated as a good species in the "Katalog," but I have not met with it, and Newport's *forficulae* has never been recognised.

Sphixapata, Rond., emen. *Sphecapata*. *Arrhenopus piligena*, Rond., is a distinct species not yet found in this country.

Nemoraea, R.-D., *nupta*, Rond., is now sunk as a synonym of *rubrica*, Mg.; *rubrica*, Mg., is, however, doubtfully distinct from *pellucida*, Mg.

Macronychia, Rond., *agrestis*, Mg. = *dumosa*, Pand.; *agrestis*, Rond. = *ungulans*, Pand. *Agrestis*, Fall., is apparently a further species which has not occurred here so far as I know.

Myiostoma, R.-D., *cristatum*, Rond., is perhaps meant for *Estheria cristata*, Mg.

Prosena, St. Farg., *angustifrons*, Meade, has not been recognised.

Idia, Mg. = *Stomatorrhina*, Rond. *Lunata*, F., is a rare insect of which I have not seen a British specimen.

Protocalliphora, Hough, see *Phormia*, R.-D.; *groenlandica*, Zett. = *caerulea*, R.-D.

Lucilia, R.-D., *sylvarum*, Mg. = *silvarum*, Mg.; *ruficeps*, Mg. = *caesar*, L.; *micans*, R.-D. (nec. Mg.) = *sericata*, Mg.; *nobilis*, Mg. = *sericata*, Mg.; *splendida*, Mg. = *caesar*, L.; *equestris*, Mg. = *illustris*, Mg.; *regina*, Mg., see genus *Phormia*, R.-D.

It will be obvious that some at least of the species which are omitted from my list because I have not met with them myself will yet prove to be British; on the other hand, some of the names in Verrall's List almost certainly represent species under other names in mine, but owing to the impossibility of examining all the specimens the synonymy has not been recognised. My list cannot be complete, and I think it better to omit many uncertainties, and so try to commence to build on a surer foundation.

VII. Appendix (B).

Stomatorrhina, Rond.

Lunata, F. Up to the eve of going to press I had seen no British specimen of this species, although Mr. Verrall had included it in his List under the name of *Idia lunata*, F., and I had therefore omitted it. At the last minute, however, Mr. J. E. Collin writes that he has seen several specimens in the Cambridge Museum, all taken by F. Jenkinson and all in 1901, from Cambridge (his own garden), Henden, the New Forest, etc.; and Mr. F. W. Edwards also writes to say that there is one further specimen in the British Museum also taken by Jenkinson in 1901, this one from the Cambridge Botanical Garden. It may be significant that these were all taken in one year, and possibly it was due to an immigration of the species. It is a very distinct and unmistakable insect, with conspicuously projecting beak-like epistoma, and the vibrissaria rather high above the same; the whole face shining black; the arista plumose on the upperside only; and the abdomen with rufous bands on the 2nd and 3rd segments, which are divided into pairs of large lunate spots.

Explanation of Plates IX and X.

Some Typical Heads of Tachinidae.

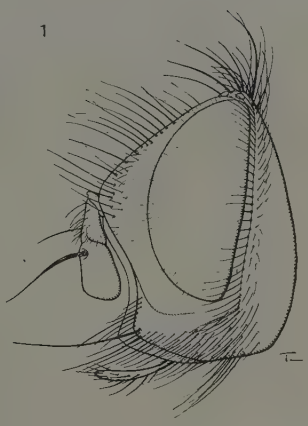
Shown in profile and diagrammatically.

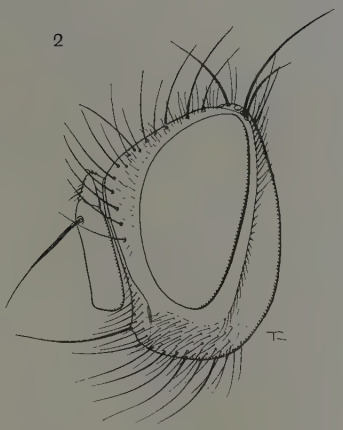
Plate IX.

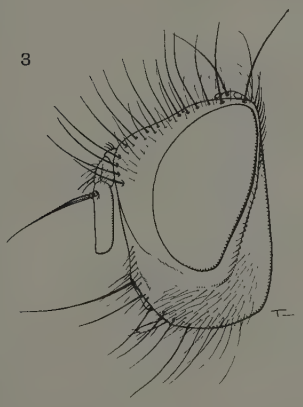
Fig. 1. *Panzeria rudis*, Fall. ♂.
2. *Phryxe vulgaris*, Fall. ♂.
3. *Meigenia bisignata*, Mg. ♂.
4. *Actia crassicornis*, Mg. ♂.
5. *Plesina maculata*, Fall. ♂.
6. *Pelatachina tibialis*, Fall. ♂.

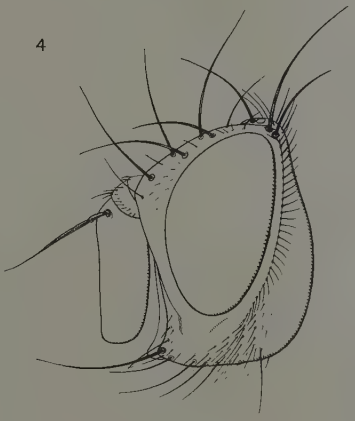
Plate X.

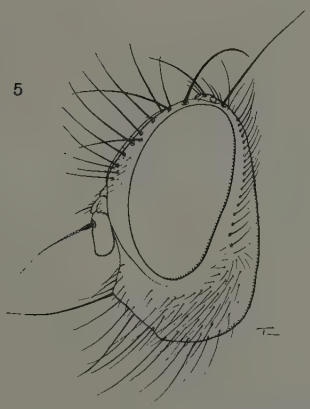
7. *Macquartia dispar*, Fall. ♂.
8. *Myiobia fuscana*, R.-D. ♂.
9. *Loewia petiolata*, R.-D. ♂.
10. *Eriothrix rufomaculatus*, Deg. ♂.
11. *Histochaeta marmorata*, F. ♂ (=*Thelymorpha vertiginosa*, Fall.).
12. *Miltogramma punctata*, Mg. ♂.

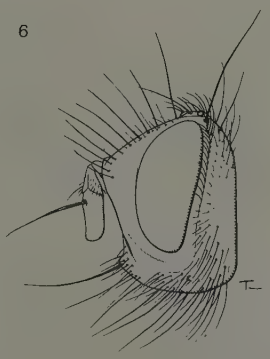












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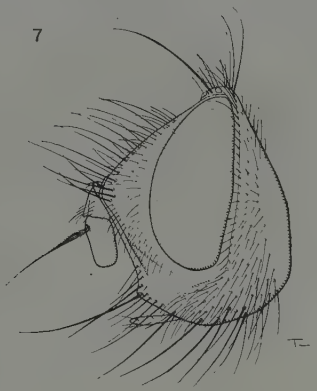

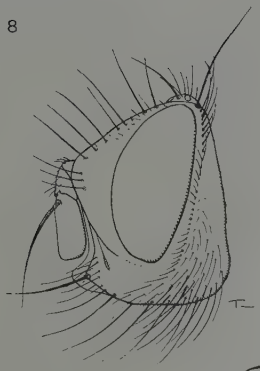

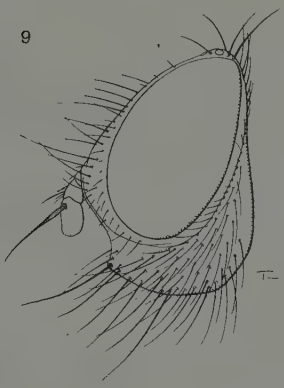

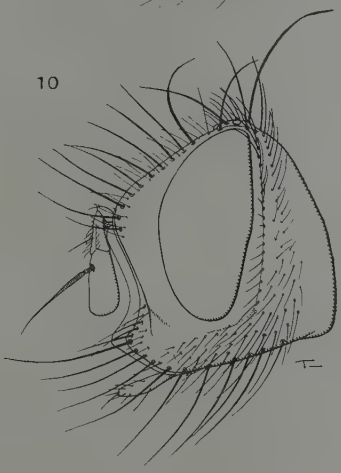

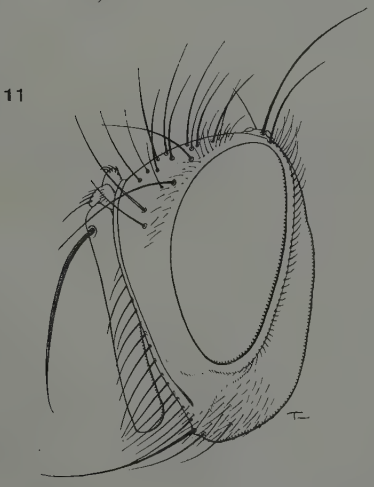

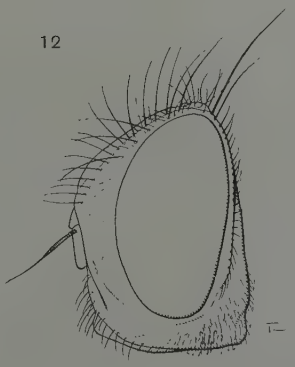

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VIII. Index to the Genera and Species.

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New Species and Variety described in this Paper.

Eriothrix rufomaculatus, Deg., var. monochaeta, n. var.
Blepharomyia collini, n. sp.
Actia verrallii, n. sp.

1929

INSECT NUTRITION AND METABOLISM

A Summary of the Literature

By B. P. Uvarov.

(Senior Assistant, Imperial Bureau of Entomology.)

[Read October 3rd, 1928.]

PREFATORY NOTE.

By Captain A. F. Hemming, C.B.E.

(Assistant Secretary, Committee of Civil Research.)

In view of material collected in Kenya in connection with work on the mineral content of natural pastures, the Committee of Civil Research in April 1926 set up a Dietetics Sub-Committee :—

> " To consider and report on the physiological and pathological conditions associated with certain rationed and specialised diets, with special reference to Kenya native tribes."

This Sub-Committee is composed as follows :—

Major Walter Elliot, M.C., M.P., Parliamentary Under-Secretary of State for Scotland (*Chairman*).
Sir Frederick Hopkins, F.R.S., Professor of Biochemistry, Cambridge University, Member of the Medical Research Council;
Professor E. P. Cathcart, C.B.E., F.R.S., Regius Professor of Physiology, University of Glasgow, Member of the Medical Research Council;
Sir Walter Fletcher, K.B.E., F.R.S., Secretary, Medical Research Council;
Dr. J. B. Orr, D.S.O., M.C., Director, Rowett Research Institute, Aberdeen;
Dr. A. T. Stanton, F.R.C.P., D.P.H., Chief Medical Adviser, Colonial Office;
Dr. G. J. Rutherford, M.R.C.S., L.R.C.P., Medical Secretary, Colonial Advisory Medical and Sanitary Committee.
Capt. A. F. Hemming, C.B.E., Assistant Secretary to the Committee of Civil Research (*Secretary to the Sub-Committee*).

In July 1926 the Sub-Committee submitted an Interim Report containing a scheme of research in regard to native dietetics. This scheme was approved, and the funds required were found by the Empire Marketing Board. Steps were at once taken to collect the research party and to start the proposed investigations.

At the same time the Sub-Committee directed their attention to other nutritional problems, the elucidation of which might throw interesting light on the work already in hand. In particular, they desired to examine the question of the nutrition of insects. The Sub-Committee found that there existed no general conspectus of the work already done in this field, and they therefore asked the Empire Marketing Board to invite the Imperial Bureau of Entomology to arrange for the scattered literature of the subject to be collected, the principal points summarised, and a full bibliography compiled. Dr. Marshall kindly

agreed to give the necessary facilities for this work to be undertaken by Mr. B. P. Uvarov. It was, however, only possible for Mr. Uvarov to do this work in his spare time, and it was therefore not until June 1928 that he was able to submit his results to the Civil Research Sub-Committee. The Sub-Committee considered that Mr. Uvarov's paper, bringing together as it does for the first time the results of all the work done in the field of insect nutrition was of the first importance and should be published in the form best calculated to secure publicity among entomological workers. They therefore invited the Empire Marketing Board to approach the Council of the Entomological Society with a view to arranging for the publication of Mr. Uvarov's paper in the *Transactions* of the Society, the cost of printing being defrayed by a grant by the Empire Marketing Board. The Board agreed to make the necessary grant; and it is thus due to their financial support that the preparation of Mr. Uvarov's paper and its publication in the *Transactions* have been rendered possible.

Mr. Uvarov's summaries of the papers, the titles of which are given in the bibliography to his paper, have been deposited in the Reid Library of the Rowett Research Institute for Animal Nutrition, Aberdeen, and arrangements have also been made for a set to be placed in the Science Library, South Kensington, where they are available for consultation by any worker interested in the subject.

A limited number of separate copies of the following paper by Mr. Uvarov are available on application to The Secretary, Committee of Civil Research, 2, Whitehall Gardens, London, S.W. 1.

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I. INTRODUCTION.

It is well known that the enormous losses regularly caused by insect pests to cultivated plants, domestic animals and human life are directly or indirectly connected with their feeding habits. On the other hand, the products of the few useful insects, like the honey-bee, silkworm, lac-insect, etc., are, from the physiological point of view, substances of definite importance in the metabolism of the insects, and their quality and output depends on the character of the food taken.

It would seem, therefore, that the problem of the nutrition and the metabolism of insects should be regarded as a key both to the successful control of injurious insects and to the progress of the industries dependent on the products of useful insects. It would be natural to expect that the attention of entomologists always has been and still is concentrated on its solution. If this were so, we might possess a thorough theoretical knowledge of the nutritional physiology of, at least, all the most important insects, and be in a position to apply it to practical purposes. The present work has been undertaken in order to ascertain what has been actually done in this field and what are the main results achieved. In order to collect this information, all available sources have been exhausted and all papers dealing with the problems of the nutritional metabolism of insects have been abstracted. A preliminary survey of the literature (before the abstracting was begun) gave promising indications, owing to the substantial number of works apparently dealing with the problem, but closer acquaintance with the literature showed that the bulk of the papers on the feeding habits, or the digestion, etc., of insects, were not physiological, but purely descriptive, anatomical or histological. Indeed, even the few existing summaries of the physiology of the nutrition of insects (Biedermann, 1911; Petersen, 1913; Jordan, 1913; see bibliography) are almost exclusively concerned with the anatomical side of the problem, while the chemical side is neglected. Analogous summaries in handbooks of entomology favour the morphological side still more, and the physiology of nutrition is usually discussed in a few general sentences.

In view of this fact, it was decided to concentrate attention exclusively on information of a chemical and physiological character, leaving out the anatomical data, which may be easily found in almost any handbook of entomology or physiology. In accordance with this decision, all the data on the chemical properties of the actual food of various insects, on the chemical constitution of insects, on the digestive enzymes, on the metabolism of the main substances, and on the influence of diets on the growth and reproduction of insects were collected. The main results are presented here in a summarised form, but the compiler would like to point out that his work is only a summary of published data, not a monograph on the subject, and that most of the data are presented without any attempt to criticise or evaluate them. Indeed, the summary should be regarded merely as a guide to the bibliography arranged by subjects. Further, it must be emphasised that the compiler is neither a physiologist nor a chemist, and the data are always presented from the point of view of an entomologist.

The first glance at the summary and, particularly, at the voluminous bibliography, including nearly six hundred titles, may give the impression that a very large amount of work has been done on the problems of insect nutrition and metabolism, but when all the data available on each particular subject are

put together it becomes clear that very few points have been touched and that the results achieved are but a drop compared with the ocean of unknown phenomena.

Thus, to begin with, existing knowledge of the food of various insects from the chemical point of view is extremely meagre. It is, of course, known that many insects feed on green plants, but the question which substances are utilised by phytophagous insects and which are not, is doubtful and has been very little studied. The problem has, however, an enormous practical importance, since the immunity of certain varieties, or species, of plants against particular insects must be closely connected with it. With regard to another group of insects of great economic importance, viz., those boring in timber, destroying forests and buildings, only one fact has so far been definitely established—that either they feed not on wood, but on fungi in the burrows, or that the assimilation of their food depends on the presence of special micro-organisms in their bodies; thus the whole problem of their nutrition is highly peculiar and still unstudied from the physiological point of view. In the case also of the blood-sucking insects which cause enormous losses in human and animal life in the tropics and elsewhere, there is practically no information on the chemical side of their nutrition, although there is a voluminous literature on the anatomy of the digestive apparatus, on the mechanics of its action, on the selection of hosts for feeding purposes, etc. Other examples of important deficiences in existing knowledge will be found in the corresponding chapters of the summary, but it is, perhaps, worth while pointing out that there is still no information available regarding the *actual* food of the larvae of the commonest insect, viz. the house-fly; it is known, that the larvae breed in various decomposing substances and that some bacteria seem to be necessary for their development, but what the larvae actually feed on has never been properly investigated. As a matter of fact, there are very few insects on the food of which there is a reasonable amount of information. Curiously enough, the insect best studied in this respect is the banana-fly (*Drosophila*), which is largely used in experiments on genetics and is therefore bred in numbers in laboratories all over the world; unfortunately, the data obtained on this insect are of very little practical value. Another well-studied insect is the cockroach, again a common laboratory species, and again one presenting but little interest to the general entomologist. The same may be said with regard to flesh-flies also very favoured in physiological laboratories, where the objects for the study are naturally enough chosen as a rule without regard to their interest for entomologists. It is the duty of all entomologists to draw the attention of physiologists and biochemists to the existence of many other insects which can be raised in the laboratory with equal ease, and which are equally interesting from physiological and chemical point of view, but are at the same time very important from other points of view.

The information on the chemical composition of insects and of their products is fairly extensive if one does not take into account the great diversity of habits of insects, which is bound to find its reflection in the chemistry of their bodies, or the stupendous number of different insect species. So far scarcely more than a few score of species of insects have been partially analysed, while complete analyses exist only in a very few cases; it is clearly impossible to generalise on the ground of such inadequate data. There is still a practically virgin field for analytical work on insects which, if carried out systematically, would be of the greatest help in understanding the nutritional requirements and the metabolic processes of insects.

Studies on insect enzymes, particularly those taking part in the digestion of food, are of obvious importance for the problem, since the presence or the absence of certain enzymes determines the availability of certain foods. Fairly extensive information proved to be available on this subject, but the proportion of doubtful data is very high owing to defective methods employed (see Chapter IV), and there is not a single insect the digestive enzymes of which have been really well studied—with the possible exception of the cockroach.

It is not surprising that present knowledge of the metabolic processes in the insect body is at a very low level, and the material available for the chapter of the summary dealing with this subject turned out to be the poorest and the most disconnected of all. It would be possible, perhaps, for a physiologist to present the information available on the subject in a more generalised way and to deduce from it certain leading ideas, but the compiler, not being a physiologist, thought it better to refrain from any generalisations, which are always dangerous, and to summarise simply the facts known.

The last chapter of the summary dealing with the influence of various substances in the diet on the growth and reproduction of insects aims at presenting all the facts known on the subject, which has been treated in the summary rather fully, because this has never previously been attempted. The data are very fragmentary and do not permit any general deductions, but in some cases they point the way to the study of very important problems in insect nutrition. In many cases, *e.g.*, with regard to the problem of vitamin requirements of insects, a great deal of controversy exists and the field for work is unlimited and very promising.

The most important part of the paper, from the compiler's point of view, is the bibliography, since this is the first time that all the literature dealing with the chemical side of insect nutrition and metabolism has been listed. The list of references is, it is hoped, reasonably complete, since no efforts have been spared to trace the papers from various sources. The literature is, however, so scattered that some lacunae possibly exist. When judging the list it must be borne in mind that only papers containing information of a definite chemical character have been included, while those dealing with the morphology or histology of the digestive or excretory apparatus have been deliberately omitted; indeed when the list was being prepared, nearly two hundred other papers had to be consulted in original, only to find that they were of no direct interest and need not be included. It is believed, that the list covers the literature up to the end of 1927 fairly completely, but a few papers published in 1928, have also been included. The first paper quoted dates back to 1671 (Wray).

The work has been undertaken at the initiative of the Sub-Committee on Dietetics of the Committee of Civil Research, and the compiler wishes to thank the Sub-Committee through their Chairman, Major Walter Elliot, M.C., M.P., for entrusting him with this interesting problem. The compiler is further very grateful to Dr. G. A. K. Marshall, C.M.G., F.R.S., Director of the Imperial Bureau of Entomology, for special permission to undertake the work and the facilities given in carrying it out. The librarians and other members of the staff in the various libraries consulted, viz. the Science Library, the British Museum (Natural History), the Royal Society of Medicine, the Chemical Society, the Imperial Institute, the Imperial Bureau of Entomology, etc., were always most helpful and the compiler finds it his pleasant duty to thank them all. The assistance in reading the proofs rendered by Miss Z. and Mr. M. Valov is gratefully acknowledged.

II. THE FOOD OF INSECTS.

(*a*) The Classification of Feeding Habits.

General books on insect biology or physiology pay special attention to the classification of insects according to their feeding habits, but the basis of such classifications appears very doubtfully scientific. Indeed, to begin with, most authors state that insects can feed and reproduce on almost any substance, and some of them even go so far as to quote examples of insects " feeding " on such impossible foods as table salt (the fly *Piophila casei* ; Reuter, 1913), or quicksilver amalgam at the back of mirrors (beetle *Niptus hololeucus* ; the same author). The reason for such misconceptions is that usually any substance nibbled by an insect is classified as its food, though in many cases this " food " never reaches the inner parts of the digestive tract, and the fragments of the substance are bitten off for reasons which have nothing to do with nutrition, *e.g.* burrows made in wood, or even in metal (lead, larva of *Sirex*). At the same time, while such *apparent* food is recorded, the actual food of the insect in question is often overlooked. It will be seen later that copious evidence has been accumulated with regard to wood-boring insects feeding not on wood, but on fungi growing on the walls of the burrows. It is clearly incorrect to apply to such insects the name of wood-eaters (xylophagous). Similarly in the case of fly larvae breeding in sacks with salt, it is obvious that they actually develop on some organic impurities in the salt, not on sodium chloride alone, which would be a physiological miracle.

Another common mistake made by authors discussing feeding habits of insects is, that more attention is paid to differences in the methods employed in obtaining food than in the actual food itself. Thus external parasites feeding on the blood of their hosts are usually classified separately from other blood-sucking insects which differ from them only in their general habits, but not at all in their nutrition. Similarly, insects feeding on decomposing vegetable and animal matter are classified differently, though it is highly probable that in both cases they feed actually on micro-organisms, or on the products of decomposition of the original substances by the activities of the latter. On the other hand, all internal parasites are classified together, though some of them may feed on fat-body, others on haemolymph, still others on the muscles, etc., of their host.

As a matter of fact, it is only in a limited number of cases that it is possible to define with some accuracy the actual food of an insect. Classifications based on apparent food are devoid of any value and serve only to cover existing ignorance in the matter. It seems better, therefore, not to attempt a general classification of insects on their food habits until these habits are better known than they are at present. (For classifications based on apparent food, see Handlirsch, 1926; Jordan, 1913; Reuter, 1913, and other handbooks of entomology and of physiology.)

Some preliminary grouping of insect food habits is of course necessary, and in the following discussion the main sources of apparent food are treated separately, with a view to determining the actual food. The grouping adopted should not, however, be regarded as a classification of insects on their food habits.

(*b*) Phytophagous Insects.

The relative number of plant-feeding insect species must be very great, since every plant (with a few doubtful exceptions) has its insect enemies.

Weiss (1914–1925*b*), who attempted to compute the relative numbers of species of insects with various food habits, came to the conclusion that about 45–50% of the species in any given area are phytophagous, while the rest are distributed amongst other groups. This figure may not be exact, being based on insufficient data, but it appears roughly correct. It is easy to see, however, that all phytophagous insects cannot be simply classified as such, since various parts of a plant present very different conditions of nutrition. Further, the methods of obtaining food from plants and the actual nutritive substances extracted differ widely in the case of various insects. It is, therefore, necessary to discuss separately insects feeding on different parts of a plant.

Leaves. Insects feeding on leaves belong to two main categories, according to the method of feeding. The first category embodies so-called *biting* insects, *i.e.* such as obtain food by biting off pieces of leaf, masticating and swallowing them. Their interest lies in the determination of the substances in leaves which serve as actual food for insects. The available data on this important subject are neither numerous nor consistent.

Acqua (1916), who made extensive studies on the nutrition of silkworms, believes that alimentation occurs mainly at the expense of proteins and soluble sugars, while amines of the leaf remain practically unutilised. Hering (1926*b*) also considers that the main source of food for Lepidopterous larvae is in the proteins of the leaf; fats and oils are also absorbed, but carbohydrates, he believes, are seldom utilised. The data of Péligot (1867), based on analyses of food and excreta, also tend to show that nitrogenous substances are very largely utilised. As regards carbohydrates, Kawase (1918) made a special study of the carbohydrates of mulberry leaves and found in them dextrose, laevulose, sucrose, starch, dextrin, araban, galactan and cellulose; of these, cellulose occurs in the largest amount, next comes a viscous substance consisting of araban and galactan, while starch is present in relatively small quantities. The actual carbohydrate food of the silkworm is therefore scarcely starch, as is usually supposed.

An important point is the fate of cellulose. The problem of digestion of cellulose by insects (p. 265) remains still not definitely solved. It is, however, reasonably clear that the vast majority of insects do not possess in their digestive juices the ferment necessary for digestion of cellulose. Since all digestible elements of plant cells are included within cellulose cell membranes, the question arises—How is the food extracted from the cells? Opinions on this matter differ. Some authors (Acqua, 1916) maintain that only such nutritive materials are utilised as are in the mechanically broken cells and the content of intact cells remains entirely unaffected by digestion; others (Biedermann, 1919) have arrived at the conclusion that all the active components of digestive juice can diffuse through cell membranes; in this way even the plasm contained in larger fragments of leaves can be fully digested. Biedermann's conclusion is based on microscopical examination of digested food and excreta. Acqua supported his views mainly on the ground of presence or absence of certain enzymes in the digestive juice. It would seem that Biedermann's view rests on more definite facts, but further research in this vital problem is clearly necessary.

A point of special interest with regard to leaf-eating insects is the fate of chlorophyll. This substance, according to Biedermann, is either simply dissolved, resorbed and transferred to the skin of the insect (Lepidopterous larvae; Poulton, 1894), or transformed into other pigments (p. 287), also deposited in the skin.

Certain special substances found in leaves such as tannin, glucosides, salicylic

and other acids, etc., seem in most cases to be without importance as food, being simply absorbed and excreted (pp. 290–291, 295).

A very interesting nutritional problem has been raised by some authors working on the silkworm, viz. the variations in the chemical composition of cell content of leaves according to season, time of the day, and position of the leaf on the tree. Thus Péligot (see Maillot et Lambert, 1905) found, for instance, that the phosphoric acid content of mulberry leaves on April 28th was 30·9% of total ash, but that the same tree on June 10th showed only 1·2% of phosphoric acid (see also Kawase, 1918). Sacchi (1919) found, further, that mulberry leaves gathered at the end of the day always contain more sugar and more proteins (formed during the day) than those picked at daybreak, which contain very little of these compounds. Thus two species of insects, living on the same tree but feeding at different times of the day or night, would be subjected to very different nutritional regimes. This point must always be taken into consideration when studying the actual food of any leaf-eating insect. Similarly, it is equally important to remember that differences in the chemical composition of leaves on the same branch of a tree, but in different stages of development, may be very great (Maillot et Lambert, 1905).

Further, some extremely interesting observations are communicated by Hering (1926, 1926*a*) on the conditions of the nutrition of leaf-mining insect larvae. In the simplest case, when a mine is sufficiently deep to include all the tissues of a leaf between the two layers of epidermis there is scarcely any difference from the free-living phytophagous insects. Many mines, however, are one-sided, *i.e.* the mine is made either in the upper (palisade) parenchym or in the lower (spongy) parenchym of the leaf. The two parenchyms are very different chemically, since the palisade parenchym serves for assimilation and is therefore rich in carbohydrates, the spongy parenchym serving for circulation of carbohydrates, which are present in a different form. This difference is, however, of little importance, since carbohydrates are scarcely assimilated by the larvae. Much more important is the fact that the proteins of the two kinds of parenchym are of different composition, and this apparently determines the behaviour of the larva. If an egg is accidentally laid on the wrong side of the leaf, the larva usually dies, being unable to feed on unsuitable proteins. Thus, even within the same leaf there may occur different nutritional conditions, and two larvae living inside one leaf may differ considerably in their nutrition and metabolism. The leaf-mining habits of larvae, even in the case of double-sided mines, may be a cause of serious changes in the composition of the leaf. This has been shown by Schneider-Orelli (1909) in the case of *Lyonetia clerkella*, the larva of which mines in leaves of apple-trees, the mines cutting off whole sections of the leaf, with the result that carbohydrates assimilated in these portions are not transferred and highly special conditions of nutrition are produced. An analogous phenomenon occurs in galls, which it will be more convenient to discuss in connection with sucking insects (see p. 264).

As regards the nutrition of *sucking* insects on green plants, *i.e.* those able to ingest only liquid food, important studies have been made by Büsgen (1891), Zweigelt (1915), Davidson (1923) and Smith (1926). The results of their observations, made almost entirely on Aphids, show that various species may feed in very different ways, since in some the proboscis penetrates the cell walls, but in others it passes between the cells and reaches the vascular bundles, etc. It is easy to see that conditions of nutrition in such conditions will be widely different even in the case of the same plant. The cell sap, which is the main

source of food for sucking insects, generally contains albuminous substances, amides, soluble carbohydrates and inorganic salts, but the constitution of sap varies in the same plant according to the development of a particular tissue, as well as in different tissues. Davidson (*l.c.*) pointed out that great stress is often laid on the value of soluble carbohydrates as food for Aphids, but that proteins have been rather neglected. The protein content of cell sap is not very high compared with carbohydrates, but, on the other hand, very large quantities of soluble carbohydrates are excreted by Aphids as "honey-dew" (see p. 294). This shows that they are present in the food far in excess of actual requirements. The large amount of ingested food may be due to the necessity of accumulating proteins from it. Detailed studies on the chemical constitution of the cell sap of different species of plants and of the excreta of Aphids living on them would throw much light on the nutritional requirements of sucking insects.

A particular case of nutrition of sucking insects is presented by Aphids living in galls. Molliard (1912, 1913) studied the chemical composition of galls as compared with normal leaves of the same plants and found great differences. In galls the ash content is particularly high, especially in sulphur, phosphorus and potassium; the sugar content of galls is less than that of normal leaves; there is no saccharose and there are less polysaccharides, but more reducing sugars and glucosides; protein nitrogen, ammonia nitrogen and asparagine nitrogen are present in galls in larger quantity, but there is less digestible nitrogen; the total nitrogen content is usually higher. All this would indicate only that very special nutritional conditions are offered by galls. The actual food of gall-making Aphids has, however, never been studied. Zweigelt (1917), in opposition to Küster (1911) and Molliard (1912, 1913), insists that there is no ground for admission that these Aphids have a generally better nutrition than the free-living ones.

When studying the nutrition and digestion of plant-sucking insects it must be borne in mind that it has been proved that they all harbour in their digestive tract, or in special organs connected with it, symbiotic micro-organisms, the rôle of which must be important, but remains wholly obscure. Buchner (1921*a*) thought it highly probable that the symbionts of Aphids and Coccids are able to assimilate nitrogen from the air, thus supplementing the deficiency in nitrogen of the normal food of the insects. Buchner, however, based this hypothesis on the assumption that the insects in question ingest only the soluble carbohydrates in cell sap, not proteins; while, as shown above, proteins and other nitrogenous substances of plant sap are probably more completely utilised by sucking insects than are carbohydrates.

Wood.—The nutrition of insects feeding on hard woody parts of plants, both living and dead, presents special physiological interest, owing to the extremely low content of wood in nutritive, and especially nitrogenous, substances. The problem is also of a great practical interest, the number of insect pests of growing timber, wood in buildings, furniture, etc., being very large and their depredations enormous.

It will, of course, be easily realised that under this heading not all insects feeding in tree-trunks and branches are included, but only those which burrow in perfectly, or almost, dead parts, containing no living cells; those burrowing in cambium find the conditions of nutrition very similar to those existing in green parts of the plant.

The ability of some insects to live and develop on a diet of dead wood is often quoted, even in physiological handbooks, as a proof of the enormous

digestive powers of insects, but this theory is gradually giving way to a very different conception of the nutritional physiology of wood-boring insects.

With regard to some bark-beetles, it has long been known that they feed not so much on the wood through which they bore, as on a special fungus growing on the walls of the burrows; more recently careful studies have been made on the subject, and the number of insects feeding apparently on wood but actually on fungi is now known to be very considerable. It is clearly unreasonable to regard them any longer as wood-feeders. They are discussed later, in the section dealing with insects feeding on lower plants and micro-organisms (see p. 268).

On the other hand, there is also a number of insects that actually feed on dry, or almost dry, wood and are perfectly able to develop on this apparently impossible diet. Here belong, as one of the best examples, the termites. Their ability to "devour" whole buildings made of timber is well known. Experiments in laboratories have demonstrated the possibility of keeping termites indefinitely on a diet of pure cellulose (cotton wool), *i.e.* the insects are able to build up the proteins of their bodies while obtaining no nitrogen in their food. The path to the solution of this physiological puzzle has been indicated through the studies of the contents of the termite intestinal tract, in which a very rich special population of Protozoa has long been known to exist. These Protozoa were formerly regarded either as parasites or as symbiotic organisms the presence of which was a matter of indifference to the host. It is mainly due to the extensive studies by Cleveland (1923–1928) that the rôle of the intestinal Protozoa of termites has been made clear. This author has examined a very large number of species of termites, and various castes of each species, with the result that Protozoa were found to be present at every stage in the life-cycle of any caste where wood is eaten; but in cases where wood is not eaten (and many species of termites do not feed on wood) Protozoa are never present. A caste which does not harbour Protozoa cannot eat wood and cannot live by itself; such individuals are dependent on the wood-eating members of the colony for support, and they feed either on the partially digested woody material of the excreta of the xylophagous members of the colony, or on the salivary secretion of the latter. Artificially defaunated termites of normally wood-eating species proved to be unable to digest cellulose and died from inanition, though continuing to eat wood. In his latest work (1928) Cleveland has shown that the matter is, however, not as simple as it seems, because some species of termites have proved able to live on pure cellulose, when freed from their intestinal Protozoa, longer than others; this tends to show that they may be able to extract some nutritive substance from cellulose without the aid of symbionts. The main point, however, still remains that, generally speaking, wood-eating termites are dependent on their intestinal Protozoa in their nutrition.

Detailed research in the anatomy, hystology and physiology of other wood-eating insects has shown that micro-organisms of various kinds are almost invariably present, either in their digestive tract or in special organs connected with the latter. A very illuminating summary of the problem was presented by Buchner in his latest work (1928). Apart from the termites discussed above, a similar type of arrangement exists in the larvae of the beetle *Potosia cuprea*, which feed on dead pine needles, *i.e.* a food very rich in cellulose but poor in nitrogen. These larvae have a special fermentation chamber of the intestine, where cellulose-digesting bacteria are harboured (Werner, 1926); analogous chambers have been found by Buchner (1928) in the larvae of Tipulidae

feeding on rotten wood. Another type of symbiotic feeding on wood and similar substances is presented by the beetle *Anobium paniceum* (Escherich, 1900; Buchner, 1921, 1928; Heitz, 1927), which has special appendages of the mid-intestine containing Saccharomycetes in their cells. Similar organs have been found in other wood-boring insects (*Harpium sycophanta*, *Leptura*, *Oxymirus*, *Rhagium*, *Ernobius*, etc.; see Buchner, 1928; Heitz, 1927). Organs harbouring symbionts have also been found in weevils feeding on wood (*Hylobius abietis*, *Pissodes notatus*), boring in stems (*Protapion aeneum* in Malva), feeding on leaves (*Cionus*) and on young fruit (*Sibina* in *Melandrium*, *Gymnetron* in *Linaria*). The whole group of Cleoninae, which feed in the heads of *Cirsium*, and all Buprestidae boring in wood also possess symbiotic organs.

While all this is only indirect evidence, since no physiological studies have at present been undertaken, it is fairly conclusive, the connection between wood-feeding habits and possession of symbiotic organisms being too regular to be accidental. There are, it is true, some cases where no symbionts of any kind have been found in wood-boring insects; an example of this kind is afforded by *Cossus cossus*, but the problem of its nutrition has never been the subject of detailed study, and this exception may be only apparent, not real. The admission of the rôle of micro-organisms in the nutrition of wood-eating insects clears the way to a better understanding of their physiology, but it must be clearly realised that the problem is still very far from being solved. Indeed, the bulk of the work on symbiotic organisms so far undertaken is anatomical, not physiological, and the actual physiological rôle of micro-organisms remains obscure. Some, like the bacteria of *Potosia cuprea* (Werner 1926), have been proved to digest cellulose; Buscaloni and Comes (1910) indicated that cellulose is digested inside the intestinal Protozoa of termites; but these data refer only to the digestion of cellulose, while the problem is much wider. The most difficult problem is not the digestion of cellulose, but how to discover the means by which the deficient nitrogen is obtained. The only suggestion made in this direction is that symbiotic micro-organisms are able to fix atmospheric nitrogen (Heitz, 1927; Cleveland, 1925), but there is no evidence of any kind in support of this theoretically very reasonable view.

To summarise, it is known that the nutrition of the vast majority (perhaps of all) wood-feeding insects is intimately connected with their symbiotic micro-organisms, but the physiological side of their nutrition remains entirely unknown. Indeed, all that is known is that the insects, apparently feeding on wood, are not actually using wood directly as food. There is, however, no evidence at all as to what substances they do, in fact, feed on; these may be particles of wood partially digested by micro-organisms, or their secretions, or their excretions, or even the micro-organisms themselves. In other words, wood-eating insects must be classified as insects of absolutely unknown feeding habits. This is an astonishing conclusion at which to arrive with regard to a group of insects of great economic importance and one which is very widely spread and of common occurrence.

Seeds. Although grain pests are another group of interest and importance, the information available on their nutrition is very scanty. Some, like *Anobium paniceum*, have special organs with symbiotic organisms (Escherich, 1900; Buchner, 1921, 1928), but the physiology of their nutrition has never been studied. Peculiar methods of feeding have been observed in the so-called harvesting ants (*Messor barbatus*, L., and others), which collect seeds of various plants into their nests and prepare from them special paste for feeding larvae (see p. 272). The ants, after bringing in the seeds, destroy their germs, and

this action has been explained as a marvellous adaptation to prevent seeds from germinating. Direct observations on ants given a choice of diet have, however, proved that they simply prefer to eat the germ and avoid the starch (Emery, 1912). In the case of insects feeding on flour prepared from grain, it has been shown that wheat germ is a very valuable source of protein and perhaps also of vitamins (Chapman, 1924). This must also hold true for insects feeding on whole seeds.

Fruit. Very little work has been done on insects feeding on various fruit. The nutritional properties of different fruits vary greatly, and no generalisations could be made even if the data available were sufficient.

In the few cases of insects feeding on fruit which have been better studied, there is evidence of the auxiliary rôle played in digestion by micro-organisms. Thus, the larva of the Olive fruit-fly, *Dacus oleae*, harbours in the blind appendages of the mid-intestine large colonies of special bacteria. The physiological rôle of these bacteria is probably connected with the fact that the larva has to ingest large quantities of oil when boring inside olives; most of the oil passes the intestine not digested, only emulsified and split up into glycerin and fatty acids. The deficiency in nitrogen may be covered by the larvae digesting some of the bacteria which have been found to be able, under certain conditions, to fix atmospheric nitrogen (Petri, 1905, 1910). Other fruit-flies, *i.e.* species of the family Trypetidae, have also been found to carry symbiotic bacteria (Buchner, 1928).

The well-known habit of the apple-worm (larva of *Carpocapsa pomonella*) of penetrating into the seed-box and eating out the seeds, must aim at covering nitrogen deficiency in the larva feeding on the pulp of the apple, rich in carbohydrates, but not in proteins. Exact studies on the nutrition even of this very common insect are, however, lacking.

Nectar.—The nectar of flowers attracts a number of various insects, which either feed on it directly or collect it for preparing special food for their larvae (see p. 271). Most of the work done on nectar as insect food has been carried out on the Honey-bee. The results tend to show that the adult bees have low nitrogen requirements, the source of nitrogen in their food being pollen taken at the same time as nectar, which contains little nitrogen (Petersen, 1912). In experiments, bees have been found to be able to live on a diet of pure carbohydrates, and it is only when worker bees are engaged in the preparation of larval food that they require proteins and obtain them from pollen (Phillips, 1927). Pollen grains pass the intestinal tract without any alteration, unless they are broken mechanically, since their cellulose shell is not affected by the digestive juice. Fat contained in pollen is scarcely utilised, the bulk of it passing through the digestive tract. As regards carbohydrates, nectar contains considerable quantities of sucrose, but glucose, lævulose and dextrins are also present; from pollen, bees can obtain the same sugars. Out of these, the three sugars can be utilised by the bee, while dextrins cannot; on the other hand, it has been proved experimentally that bees can utilise a number of carbohydrates with which they never meet normally (Phillips, 1927; see p. 295).

Nenjukov (1927) has recently studied the digestive enzymes of the butterflies *Pieris brassicae* and *Vanessa urticae* feeding, apparently, exclusively on nectar, which contains hardly any nitrogen. Only enzymes acting on carbohydrates were found. This means that butterflies are able to dispense with nitrogen and to form their genital products at the cost of reserve proteins and fats.

Fungi. Though the number of insects feeding on higher fungi is considerable, no work apparently has ever been done on the physiology of their nutrition,

which is bound to present some peculiarities. One side of the problem has been touched by Kemner (1926), who stated that a Javanese beetle, *Platydema tricuspis*, is able to digest the chitin of the fungus on which the larva feeds, but Schulze (1927) showed that only partial digestion of chitin takes place. No attempt has been made to ascertain whether any micro-organisms responsible for the digestion are present.

As regards lower fungi, a considerable literature exists on the subject of fungi cultivated for food by wood-boring "ambrosia beetles" (Hubbard, 1897; Hopkins, 1898; Neger, 1908*a*, 1909; Baumberger, 1919); by termites (Petch, 1913); and by ants (summary by Wheeler, 1907, who also summarises information regarding fungus-growing termites and ambrosia-beetles; Bequaert, 1922). Schneider-Orelli (1913) and Neger (1908*b*, 1910) described the fungus-feeding habits of CECIDOMYIDAE inside galls. The bulk of the literature is, however, descriptive, not physiological, and the actual conditions of nutrition even of the ambrosia-beetles have not been studied. The term "ambrosia-beetles" has been introduced by Hubbard (1897) as a convenient one to distinguish from the true bark-borers and bark-eaters, the timber-boring beetles, which push their galleries deeply into the wood, and feed not upon wood, but on certain minute and juicy fungi propagated on the walls of their galleries; this food is called ambrosia. The fungus is constantly cropped by beetles and their larvae; if ambrosia accumulates, ripens and discharges its spores, it chokes the galleries and the inhabitants are suffocated. Various beetles cultivate different species of ambrosia, and numerous adaptations for transferring spores of fungus into new galleries have been described by various authors; but this side of the question does not concern the present inquiry.

The *yeasts* undoubtedly serve as direct food for many insects apparently feeding on decaying and fermenting fruit and other vegetable matter, but it would be more convenient to discuss them with other saprophagous insects (see below). The same applies to *bacteria*, though Atkin and Bacot (1917) have cited an instance of an insect feeding almost entirely on bacteria; these were larvae of the mosquito *Stegomyia fasciata*, which were able to thrive on bacteria in the absence of any other food. It is highly probable that many of the insects living on soil feed on bacteria, but there are no observations available on this point.

(*c*) Saprophagous Insects.

Insects feeding on decaying and fermenting organic matter are always classified as saprophagous, but it is necessary to define more closely the meaning of this feeding habit.

DECAYING VEGETABLE MATTER. A typical example of an insect feeding on fermenting vegetable substances, particularly on fruit, is offered by *Drosophila*, a fly very much used in laboratories for genetic studies. As the result of this fly having been bred in large quantities, some valuable data have been obtained on the nutrition of saprophagous insects. It has been found (Guyénot, 1913; Delcourt et Guyénot, 1910; Loeb and Northrop, 1916, 1917*a*; Northrop, 1917; Baumberger, 1919) that in all natural feeding media of *Drosophila* larvae yeast is always present. Direct experiments show that the larvae grow very slowly on sterile food and die before pupating, but the rate of growth can be increased by introducing live yeasts. This means that decaying fruit is not the actual food of *Drosophila*, but merely a substratum for yeast cells, since the simplest artificial nutritive medium for yeast, if infected with yeast, is equivalent to fermenting fruit in the development of *Drosophila*. Fruit,

however, has some additional nutritive value. Dead yeast proved to be an equally adequate food for larvae, and this indicates that the principal function of yeast is to serve as a source of proteins (Northrop, 1926).

Similarly, larvae of a Cecidomyid fly, *Miastor* sp., living under rotting bark of dead trees feed not on decaying wood, as might be supposed, but on the micro-organisms present. It was found possible to breed the larvae on an agar culture of the micro-organisms, but not on sterilised bark (Harris, 1923).

It would thus seem that the name "saprophagous" as applied to such insects is far from being correct; as a matter of fact, they are phytophagous and feed not on decaying vegetable matter but on living microscopic plants and other organisms.

Decaying Animal Matter. The nutrition of larvae of flesh-flies apparently feeding on decaying meat has been the subject of a series of studies. While Fabre maintained that the larvae produce a proteolytic enzyme which liquefies meat, Guyénot (1906, 1907), Bogdanow (1906, 1908) and Baumberger (1919) considered that the food is liquefied by bacteria and that without the latter the larvae are unable to develop. More recently Wollmann (1911, 1921, 1922) insisted that it is possible to breed sterile larvae on sterile food, and that they developed in his experiments in a perfectly normal way. The absolute necessity of bacteria for the nutrition of larvae is, therefore, doubtful, but this hardly affects the fact that normally the larvae develop on a substratum already liquefied by bacteria. In any case, it is worth pointing out that even this classical object of physiologists is still very imperfectly studied from the nutritional point of view.

Coprophagous Insects. The term "coprophagous" is generally applied to all insects feeding on the excreta of other animals, but its validity appears doubtful, since excreta of various animals differ widely in their constitution.

One of the best known coprophagous insects is the house-fly, *Musca domestica*, and it would be natural to assume that its physiology is thoroughly well known. This is, unfortunately, not the case. Hewitt (1914), in his otherwise excellent monograph of the insect, produced a long summary of substances in which larvae of house-fly can breed; but his only conclusion was that the larvae are able to breed in various excreta and in rotting animal and vegetable matter, especially when they are in a fermenting condition. Baumberger stated (1919) that house-fly larvae are never found in any materials that are not infected with micro-organisms, and it appears to him very probable that the latter serve as direct food for the larvae.

Vaternahm (1924) studied the nutrition of dung-beetles, *Geotrupes*, and found that the bacteria of dung do not play an important part in it, and that feeding on sterile food has no harmful effect.

(*d*) Carnivorous Insects.

Although only such insects as feed on other insects and animals smaller than they are themselves are usually regarded as carnivorous, it is really more correct to include in the same category also external and internal parasites, as well as the free-living insects that suck the blood of higher animals, since they all feed on the ready nitrogenous substances of animal bodies. Of all these groups only blood-sucking insects have been more or less studied with regard to the physiology of their nutrition, while there is no information (apart from occasional records of digestive enzymes; see p. 295) on the nutrition of other groups.

Blood-sucking Insects. There exists a voluminous literature on the feeding habits of certain blood-sucking flies, more especially of tsetse flies

(*Glossina*), but nearly all of it is of little direct value for the present purpose. Indeed, observations on the feeding of tsetse flies on various animals, or the determinations of hosts by analysing the stomach content of flies, are very important for the study of the general habits of the flies, but not of their physiology (information of this kind has been summarised by Newstead, 1924). The only physiological data are those contained in the papers by Roubaud (1909, and, especially, 1919). According to this author, the adult flies are absolutely haemophagous (though instances of feeding on substances other than blood are given by Newstead, 1924); moreover, they can normally live only on the blood of warm-blooded animals, being able to feed, but not to reproduce on the blood of some reptiles. This tends to show that the chemical requirements of the flies are very restricted. The blood ingested by flies is digested only in the middle section of the digestive tract, where the epithelial cells include symbiotic yeast-like organisms which apparently play some part in the digestion of blood. All other blood-sucking Diptera are unable to live on blood alone and require, at least, water to supplement it; they do not harbour symbiotic organisms. It may be concluded that the strict haemophagy of tsetse flies depends on the presence of symbionts. Stuhlmann (1907) also was inclined to think that digestion of blood by tsetse flies is a symbiotic process. This author states that serum of the ingested blood is simply absorbed in the intestine, while the blood corpuscles must be digested first, and that this is done, probably, by means of a peptase or a protease. (On the nutrition of tsetse-fly larvae see below, p. 272.) This forms practically all the data on the chemical side of nutrition in tsetse flies. One cannot help expressing surprise at the almost complete ignorance on this important subject, concerning one of the worst enemies of mankind.

Scarcely better information exists with regard to the nutrition of mosquitoes. Feeding habits of adult mosquitoes have been very carefully reviewed by Howard, Dyar and Knab (1912), who found that certain species have a decided predilection for the blood of certain animals. Thus, the yellow-fever mosquito probably feeds exclusively on human blood and even discriminates between different races of man. More observations have been made on feeding habits of mosquitoes since that review, but the chemical side of their nutrition has never been touched. (Some supplementary data, see Knab, 1907; Genna, 1923.)

Only very fragmentary evidence is available on the food of other blood-sucking insects. Roubaud (1913) studied feeding habits of blood-sucking larvae of the fly *Auchmeromyia*; they feed on the blood of mammals with hairless skin, and blood is digested without haemolysis. Weinberg (1908) discovered that larvae of *Oestrus*, which attach themselves to the walls of the intestinal tract of horses, feed occasionally on blood (their main food is absorbed directly from the contents of the host's intestine); they are able to secrete a substance coagulating blood and dissolving red corpuscles.

(*e*) Insects feeding on Special Substances.

Keratin. A review of Lepidopterous larvae feeding on horny substances has been produced by Joannis (1897), but this work does not touch the physiological side of the problem. Sitowski (1905, 1910) studied nutrition of the larva of the clothes moth (*Tineola biselliella*), which feeds on hair, and came to the conclusion that the keratin of the hairs is very little utilised and that the alimentation occurs mainly at the cost of fats and remnants of protein on the

hairs. This conclusion has been very conclusively contradicted by Titschak (1922; also 1926). This author found that larvae of the clothes moth can be bred on a variety of substances, but, when choice is possible, they always prefer the substances containing keratin. Feeding experiments with wool proved that keratin undergoes a fermentative digestion and the quantity of undigested keratin in the excreta is very small, while the bulk consists of digested keratin. The digestion of keratin is further demonstrated by the fact that the hairs contained only 2·23—2·58% of sulphur, but that in the excreta the sulphur content reached 4·03—4·62%. This means that keratin was digested, its albuminoid part absorbed as well as its carbohydrates—fat, and that the parts containing sulphur were excreted. The digestion of keratin is very slow and the food takes two to four days to pass the digestive tract.

Wax. The larvae of the moth *Galleria melonella* feed on the combs in bee-hives, and it has been assumed that they are able to develop on wax alone, though it does not contain nitrogen. Investigations by Sieber and Metalnikow (1904) demonstrated that the larvae do not grow if fed on pure wax, and they cover their nitrogen requirements by eating fragments of cast skins of bee larvae and other similar matter always present in natural combs. On the other hand, the larvae do not grow on other foods rich in nitrogen unless some wax is added, and analyses of the excreta show that more than half of the wax in the food is utilised. Wollmann (1911) has shown that larvae of *Galleria* can be bred on wax aseptically, *i.e.* they do not require micro-organisms to assist in the digestion of wax.

Silk. A case parallel to feeding on keratin is that of a beetle, *Anthrenus museorum*, which in Abderhalden's experiments (1925) proved to be able to develop on a diet of pure silk, *i.e.* on amino-acids only, without any fats or carbohydrates. Thus the insect is able to build from amino-acids all the substances of the larva and the beetle, viz. carbohydrates, fats, proteins and chitin. Apparently no attempt has been made to ascertain whether any micro-organisms (symbiotic or free living) take part in the digestion of silk.

Other Substances. There are scattered literature records of insects feeding on various unusual substances, some examples of which have been quoted above (p. 261). Amongst other cases of the same kind may be mentioned the beetle *Trigonogenius globulum*, which can breed in argol, *i.e.* the deposit separating out in barrels of new wine and consisting mainly of potassium bitartrate; the insects failed, however, to develop on pure potassium bitartrate, which shows that they actually feed on some substance mixed with the argol (Scott, 1921).

(*f*) Insects feeding on Specially Prepared Foods.

There are a number of insects which feed their young on specially prepared foods; food of this kind has been studied chemically only in one case, that of honey-bee larvae.

Honey-bee Larvae. All bee larvae in their earlier stages are given by worker bees the same kind of food, the so-called "royal jelly," which is a gummy paste of milky-white colour prepared in the pharyngeal glands of workers from predigested pollen. This food is very rich in proteins and fat. It is given to the queen larva throughout its life-time, but the worker and drone larvae have their diet changed during the third day of their life, after which they receive a mixture of pollen and nectar (or honey). This latter food has a much higher carbohydrate (sugar) content than the royal jelly, but much less fat and nitrogen, the latter being contained in pollen grains, which

are usually cracked by the workers to make their content available to the larvae. This change of diet is responsible for the differences of the queen bee from workers and drones (see p. 311). The literature on the subject is very extensive, and no attempt is made to review it fully; the most important original works are by Henneberg, 1877; Planta, 1888; Nelson, Sturtevant and Lineburg, 1924; Snodgrass, 1925; Parker, 1926; Bertholf, 1927.

Other Insects. Many termites feed their larvae on disgorged liquid food, apparently analogous to the royal jelly of bees, but neither the source of the food nor its constitution are known. The food must be very easily digested, and such members of the colony as are fed on it usually become free of the intestinal Protozoa which assist termites in the digestion of cellulose (see above, p. 265). (Cleveland, 1923, 1925.)

Somewhat similar arrangements are known for ants, with regard both to the members of their own tribe and to the numerous "guests" (beetles, etc.) living in the ants' nests. All the information, however, is of an ethological character, and no data of physiological or chemical interest are available. Harvesting ants (*Messor* spp.) collect seeds of various plants into their nests, where they are shelled and their germ removed (see p. 266). They are then masticated by workers and made into paste, which is dried in the sun. Since the dried paste is hardly suitable as food owing to its hardness and because the nutritive substances in it are still in the form of starch and aleuron, it seems probable that an enzymatic action of a fungus is necessary to make the food available for nutrition; this rôle perhaps belongs to *Aspergillus niger*, which commonly develops on the paste (Neger, 1910*a*). Emery (1912), however, believes that the paste is fed to larvae as it is, without the intervention of ferments or of fungi.

Larvae of tsetse flies offer another interesting case of nutrition. They pass all their larval development inside the body of the female and feed on the secretion of special nutritory glands; the secretion is a milky-white emulsion corresponding to the milk of mammals; it contains a large number of small granules, some of which are fat, but most are albuminoid. The secretion is ingested into the intestine of larvae, but no digestive processes can be observed; instead, the fat from the secretion is absorbed directly through the epithelium and the remaining liquid becomes gradually very rich in proteins. The larva thus feeds only on fat. There is no assimilation of proteins in this stage, but in the pupa use is also made of them.

(*g*) Atrophic Insects.

Special mention should be made of insects which do not take any food during their adult stage. Here belong, for instance, some moths, in which even the mouth-parts are not developed; they live on reserve materials accumulated during the larval-feeding period, but their activities are, of course, restricted and their life is relatively short. All insects with complete metamorphosis, of course, have a period during the pupal stage when they do not take any food.

(*h*) The Selection of Food.

The food requirements of various insects are plastic in differing degrees, *i.e.* some insects can develop on a great variety of foods, while others are highly specialised in their requirements and restricted to a single kind of food.* In

* The problem of the attraction of insects by various foods and chemicals (chemotropism) is not discussed in the present work; it is closely connected with feeding habits, but not with the chemistry of nutrition.

some cases the highly polyphagous habits may be only apparent; thus, larvae of *Drosophila* develop on a great variety of media. These media, however, only serve as a substratum for yeast, which is the actual food of the larvae. The problem of food selection has been best (though still very insufficiently) studied in the case of phytophagous insects, particularly Lepidopterous larvae, feeding on higher plants.

Lepidopterous Larvae. General reviews of food habits of Lepidopterous larvae, in the shape of lists of food-plants of various species of Lepidoptera, have been published by many authors, but such lists are of relatively little value for the solution of the problem: what are the causes of selection of food-plants by larvae? This problem must not be, of course, confused with another, closely connected biologically but very different physiologically, *i.e.* that of selection by females of plants on which to lay their eggs. It is generally true that females lay eggs only on the plants suitable as food for the larvae, but this action is clearly not connected with nutritional requirements of the female, which itself feeds on the nectar of quite different plants. On the other hand, if eggs are deposited on an unsuitable plant, the larvae may die of starvation, unless they are able to find a suitable food-plant.

In some cases the chemical causes of the selection of the food-plant seem to be clear. Thus the larvae of *Pieris brassicae* and *P. rapae* (cabbage butterflies) feed on various Cruciferae, and also on Tropaeolum, Reseda and some Capparidaceae. All these plants are characterised by the presence of special glucosides, viz. mustard oils (alkyl-*iso*-thiocyanates). These oils appear to attract the larvae, since it has been found that they will attack any plant smeared with mustard oil (Verschaffelt, 1911). No work, however, has been done on the question whether the glucosides have any real metabolic importance for the larvae, *i.e.* whether the larvae are actually able to develop normally on a diet without them (if they can be induced to take it). On the other hand, the mere fact that larvae begin to eat other plants smeared with mustard oil does not prove that they would develop on them. The importance of plant glucosides from the nutritional point of view has been stressed by Axenfeld (1903), who has pointed out that they must be of special importance with regard to the selection of food by insects, since most glucosides are poisonous (*e.g.* amygdalin); and that the insect must not only possess a special enzyme for the utilisation of a sugar from a special glucoside, but also must acquire immunity against the poison.

Another substance of some importance for the present problem is exemplified by tannin. Grevillius (1905) made very extensive feeding experiments with caterpillars of *Euproctis chrysorrhoea*, which showed that they prefer plants rich in tannin, such as oak, chestnut and beech; Stellaria media, which contains no tannin, is never touched, but some plants with low tannin content, *e.g.* fruit-trees, are eagerly eaten. Degeener's investigations (quoted by Grevillius, *l.c.*) showed that tannin is scarcely, if at all, absorbed in the digestive tract of the larvae and is practically all excreted; Hollande (1923) also observed that tannin ingested by larvae of *Tortrix viridana* feeding on oaks is accumulated in the cells of the intestinal epithelium. This seems to indicate that tannin does not play a direct part in the nutrition of the larvae. It may, however, be of indirect importance, either as an attractant, or in the digestive processes. (See also Lagerheim, 1900.)

Crystals of organic salts in plant cells may be of importance in the selection of food-plants. The larva of *Chaerocampa elpenor*, for example, normally feeds only on plants containing calcium oxalate crystals, though it may also be

successfully bred on others; at the same time the crystals are abundant in the excreta, *i.e.* calcium oxalate is scarcely, if at all, utilised (Netolitzky, 1922).

Thus it would appear that the evidence on the value of special substances in plants for the selection of food by insects is contradictory, and further research is necessary. The work must be done on the lines of testing the influence of presence, or absence, of certain substances in the diet on the *development* of larvae. This has never yet been done.

Hering (1926, 1926*a*, 1926*b*) is inclined to think that the specific proteins of various plants constitute the main factor influencing the choice of food by Lepidopterous larvae. Biochemical studies on plants have shown that the affinities of proteins of different plants can be determined by serodiagnostic reactions. It is interesting to note the marked parallelism between the affinities of plants as demonstrated serodiagnostically, and the selection of these plants as food by insects. For example, the larva of the leaf-mining moth *Tischeria complanella* makes mines in leaves of oak and chestnut, and the serodiagnostic reaction shows that proteins of these two plants are closely allied. Hering quotes numerous examples in which lists of food-plants of leaf-mining larvae are in close agreement with the affinities of plant proteins determined serodiagnostically. He considers that leaf-miners are even more sensitive than the serodiagnostic reactions, since, *e.g.*, no reaction can be obtained between Graminaceae and Juncaceae, though species of *Elachista* make mines exclusively in plants of these two families. The importance of proteins in the selection of food is, of course, explained on the ground of their special importance in the nutrition of leaf-eating insects (see p. 262), but Hering himself admits that there are some cases when selection of food-plants is clearly not connected with the protein differentiation of food-plants and must be explained on other grounds.

Brues (1920) is not inclined to accept the view that the dependence of monophagous or oligophagous insects upon specific plants rests on a physiological basis. His main argument against this theory is that, to accept it, it would be necessary to assume "that the digestive functions of the cercopia caterpillar with its sixty-odd food-plants were fundamentally different from those of monophagous caterpillars." This argument is not very convincing, since the specificity of digestive enzymes seems to be more probable than is usually assumed (see p. 296).

Sucking Insects. The problem of resistance, or of complete immunity, of certain varieties of cultivated plants against attacks by Aphids and Coccids is a very important one. The most obvious example of this kind is in the resistance of American vines to *Phylloxera*, but the whole enormous literature on this insect contains very few papers dealing with the problem; the bulk of literature on resistance of vines is confined to lists of immune varieties, and has no value from the physiological point of view. Indeed, it is surprising, but is nevertheless a fact, that existing knowledge of the physiology of this very much studied insect is extremely inadequate. Boutin (1876) attempted to explain the resistance of American vines against *Phylloxera* by the presence in them of "a resinoid substance" absent from French vines, but the rôle of this substance is, apparently, in the healing of the wounds caused by the insects, so that it has no relation to the nutritional problem. Petri (1910*a*) studied the acidity and sugar content in the roots of various vines, and found that both vary seasonally in a greater degree than the differences observed between more and less resistant varieties; thus, neither the acidity nor sugar content can be of direct importance. This view is not shared by Comes (1916), who believes that greater acidity of vegetable juices presents a defence of plants against insect enemies,

including *Phylloxera* and other Aphids; the views of this author are largely theoretical. The influence of the quality of food on the rate of development in *Phylloxera* is stressed by Börner (1927), who says that the development of the insect on the resistant vines is slower, although the insects feed freely. The whole problem is, of course, complicated by other factors of resistance not of a nutritional character, but there is scarcely any doubt that, at least, a partial solution of the problem might be attained by detailed studies of the physiology of the nutrition of the insect and of the actual sources of its food. Both these subjects remain little known.

Another Aphid, presenting an analogous problem, is the Woolly Aphis of apple-trees. Different varieties of apple are very unequally affected by the insect, and some are quite immune from its attacks. Again, the bulk of the literature on the subject is represented by lists of more and less resistant varieties. The data on the possible causes of the resistance are very meagre, and the problem has never been studied from the physiological point of view. French (1891) analysed the ash of two varieties of apple-trees, one being a crab-tree much infected by Woolly Aphis, the second, the Majetin, being quite free from infection. The results showed that the second variety contained much more lime, and the author thought it probable that the resistance is due to this substance. Monzen (1926) attacked the problem from another point of view. His analyses of branches of susceptible and immune varieties showed that the immune varieties contained more malic acid than the susceptible ones. Experiments were arranged with breeding Woolly Aphis on cut branches of apple-tree put in a nutrient solution, without, or with, the addition of alkali or acid. The experiments demonstrated that the Aphids which were fed on branches growing in the nutrient solutions showing the greater PH value were more productive than those fed on branches growing in solutions with smaller PH value; in other words, the Aphids are more productive on the apples growing in the alkaline nutrient solution than on those growing in the acid solution. This suggests a possibility of increasing the resistance of apple-trees by using acid fertilisers.

Very suggestive experiments on similar lines were arranged by Müller (1926), by introducing water solutions of pyridine and of aluminium sulphate into branches of apple-trees with Woolly Aphis. Aluminium sulphate proved to be more effective in weak solutions (1 : 10,000); pyridine was the most effective of the solutions tried, and wholly harmless to the plant. In every case the Aphids were not killed, but simply left the branch.

These experiments are important as demonstrating that it is possible to introduce into plants certain substances which make the plant immune from attacks by an insect, without necessarily killing the latter. Empirical evidence is in favour of such substances as alcohol or pyridine rather than the solutions of salts, but this is clearly a nutritional problem, and the solution of its practical side can be hardly expected until the influence on the insects of the substances introduced is studied thoroughly. For the control of sucking insects the method seems to be very promising, but its elaboration cannot be based on haphazard experimenting with various substances.

Insects Feeding in Fruit. Savastano (1914) compared the sugar content and acidity of different varieties of Citrus in various provinces of Italy with the severity of attacks by the Citrus fruit-fly (*Ceratitis capitata*), and arrived at the conclusion that the latter does not attack the Italian lemons at all. As regards other fruit, his conclusion was that cultivators trying to increase the sugar content and to reduce the acidity of fruit breed varieties more susceptible to

attacks by the fruit-fly. Oranges and tangerines are attacked most, because they are sweeter and less acid. While these observations are suggestive, they are faulty in the sense that they confuse two distinct issues, viz. acidity and sugar content; they are, of course, interdependent, but it would be important to find out which of the two factors has the more value. This is again a nutritional problem, and must be attacked as such.

Another highly important insect is the apple Codling moth (*Carpocapsa pomonella*), which attacks different varieties of apples in a very unequal degree, but no attempt so far has been made to study the connection between the chemical properties of fruit and their degree of resistance against the insect. Generally speaking, the study of this problem of resistance could, perhaps, be best solved by studies of fruit-feeding insects, but first the insects themselves should be studied from the point of view of their diet and of the changes in the latter with the ensuing result.

Other Insects. Oshima (1919) made an extensive study of termites damaging wooden buildings in the Philippine Islands, and found that of all timbers used teak and cypress were absolutely immune from termite attacks; the immunity is due to the presence of sesquiterpene alcohols. In this case, since termites do not feed directly on wood (see p. 265), the presence of certain substances in their food was evidently harmful not to them, but to their intestinal Protozoa, and this brings out a very interesting conception, that resistance of plants against insects feeding on them indirectly (with the help of symbionts or on fungi cultivated in burrows, etc.) may be due to the unsuitability of the plant for the organisms symbiotic with the insects. In other words, from the point of view of control in such cases the best line of attack would be not against the insects, but against their symbionts. If a plant can be rendered immune against the ambrosia fungus of a certain beetle, it will be immune from attacks by the latter. This is a purely theoretical suggestion, but one worth studying most carefully, since the practical results may be very great.

III. THE CHEMICAL COMPOSITION OF INSECTS AND OF THEIR PRODUCTS.

(*a*) Ash.

Determinations of the ash content of insects are apt to contain considerable inaccuracies and mistakes, owing to the fact that most insects are very small and very large numbers of them are necessary in order to obtain sufficient quantity of ash for the analysis. Further, practically all analyses are to be made on whole insects, *i.e.* the contents of the digestive tract (food) are always included in the analysis, though there is no doubt that certain mineral substances pass the digestive tract without being utilised. Similarly, certain excretory products are stored in various organs and parts of the insect body, often in relatively large quantities (urates and calcium salts in the Malpighian tubes, etc.), and the total analyses show these products as constituents of the body which, in fact, they are not. The only partial analyses made so far refer to the blood of insects, owing to its special physiological interest and to the relative ease with which it can be isolated. (See table on p. 277; also Bishop, Briggs and Bonzani, 1925.)

Total Ash. The total ash content of insects varies considerably. Abderhalden (1923) found that it varied in the larvae of *Deilephila euphorbiae* from 3·26% to 9·87% of the dry weight. Davis (1917) determined the crude ash content of larvae of *Lachnosterna* as 2%, while in the adults it was 1·6%.

TABLE OF ASH ANALYSES OF INSECTS.

Insect.	Reference and remarks.	K.	Na.	Mg.	Ca.	Zn.	Cu.	Al.	Si.	P.	As	S.	Cl.	Mn.	Fe.
Honey-bee (drones).	Aronssohn, 1911 (figs. in text).	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Silkworm.	Peligot, 1852 (p.c. total ash).	36·0		9·3	8·3				3·9	29·0		1·9	1·1		×
Do.	Lenz (do.).	49	36	8·48	5·92				0·57	28·71		6·22	×		0·71
Do., eggs.	Peligot, 1852 (p.c. total ash).	29·5		10·3	6·4					53·8					
Do., shell of eggs.	Lavini, 1834.	×		×	×				×	×		×			×
Do., yolk of eggs.	Tichomiroff, 1885.		×	×	×					×		×			
Caterpillars.	Mayer, 1896.	×	×												×
Pieris, blood of larva.	Brechner, 1925.	×		×	×					×		×	×		×
Melolontha.	Dingler, 1927.	×			×					×					
Do.	Farsky(p.c. ash).	10·74	3·39	13·41	11·33				11·12	42·09		11·12	0·38		6·41
Do.	Fricker, 1885.	×								×					
Do. (normal).	Slowtzoff, 1904.	13·48	4·53	1·97	18·27					31·63		16·36	4·64		5·53
Do. (starved).	Do.	17·30	6·72	2·59	11·60					32·03		16·59	3·01		7·23
Do.	Wollf, Funke u. Dittmann.	37·36	5·66	8·41	2·86				1·73	41·82		1·28	0·36		0·71
Lepidoderma spp.	Jarvis, 1923 (p.c. total weight).	1·75			0·27				1·66	0·16					
Cantharidae.	Kübly, 1886 (p.c. ash).	14·97	2·84	9·67	19·05				14·90	32·07		1·00			
Calandra.	Henry et Bonoure.			×	×				×	×		×			×
Blaps ambusa (integuments).	Hornung u. Bley.			×	×				×	×				×	×
Timarcha, blood.	Carlier et Evans, 1911.	×	×	×						×			×		×
Blood of Lepidoptera and Coleoptera.	Griffiths, 1892.	4·06 4·20	43·29 44·03	1·00 1·16	2·02 2·96					3·21 3·61		2·80 2·92	41·30 13·16		0·08 0·10
Blood of insects.	Muttkowsky, 1921, 1923.	×	×	×	×		×			×	×	×	×		×
Schistocerca paranensis.	Künckel, 1899.	×		×	×					×					
Do., eggs.	Schroeder, 1909 (p.c. total dry weight).	0·40		0·37	0·03					0·21					0·21
Do., larvae.	Do.	0·80		0·16	0·02					1·40					0·16
Do., adults.	Do.	0·76		0·32	0·01					0·70					0·12
Melanoplus.	Packard, 1878 (p.c. ash).	7·42	5·08	8·51	13·26				12·1	50·71		1·05	1·76		
Do.	McHargue, 1917 (p.c. total dry weight).	1·20	0·34	0·39	0·36				0·60	1·19		0·38		0·008	0·11
Blattella germanica, blood.	Haber, 1916 (spectroscop.).	×	×	×		×	×	×							×
Zygoptera, larvae.	Birge and Juday (p.c. total weight).			0·03	0·84			×	0·54	1·50					
Sialis, larvae.	Do.			1·12	0·16			×	0·33	1·46					×
Chironomus tentans, larvae.	Do.			0·46	1·30				0·32	2·10					
Integuments of insects.	Odier, 1823.	×			×				×						×

Note.—The data on Bo, Tl, Pb, I, F and Ni are not included in the table and can be found in the text. A cross means that the element was determined only qualitatively. The percentage figures have different meanings, as explained in each case, and are not comparable. Only two places of decimals are given in the table, even though in some cases the author quotes more exact figures.

McHargue (1917) found in the moisture-free ground-grasshoppers (*Melanoplus* sp.) 5·61% of crude ash. Peligot (1852) found that the ash content of silkworms fluctuated from 4 to 11% according to age (see p. 308), though in the eggs the percentage of ash was 3·6%. Slowtzoff (1904) obtained very high figures of the ash content of *Melolontha melolontha*, namely 15·49% in the normal beetles and 11·08% in those dead from inanition. Only the soluble ash was determined in the larvae of *Malacosoma americana* by Rudolfs (1927), and very great variations according to the development of the larvae were observed (see p. 307), the total percentage varying from 0·41 to 7·37%.

All the comparatively full ash analyses that have been published of various insects have been collected in the table given on p. 277. The figures of percentage or of the actual content have different meanings, as explained in each case, and are not comparable; when only the presence of a certain element is recorded a cross is put in the table. The records of incomplete analyses, *i.e.* those containing only one or two elements, are not included in the table. They are, however, mentioned in the discussion of the data referring to each element.

Potassium. The high percentage of potassium salts in silkworms and their eggs, and to a lesser extent in *Melolontha*, shows that this element may be of great importance in the composition of the insect body, but it must be remembered that potassium salts may be largely excretory products. Thus, there is apparently no potassium in the yolk of silkworm eggs (Tichomiroff, 1885), but their shells consist mainly (as far as the mineral part is concerned) of potassium silicate, sulphate and carbonate (Lavini, 1834). It will be seen later that excretory products are often stored in the egg-shells of insects. Latter (1892, 1895, 1897) described the emission of potassium hydroxide by the moth *Dicranura vinula* on its emergence from the cocoon; if the pupa were analysed, a very high percentage of potassium may be expected, but it would be wrong to regard it as a constituent of the body. Analogous observations have been made by Urech (1890) on other Lepidoptera.

Bunge (1874) made special determinations of potassium and sodium content of the ash of Lepidopterous pupae and found that in some cases (*Pygaera bucephala*) there was as much as 50·69 units of K_2O to one unit of Na_2O.

Sodium. Although the percentage figures for sodium in the ash are seldom high, this element seems to be very commonly distributed in insects. A specially high sodium content has been observed in the blood of Lepidoptera and Coleoptera (Griffiths, 1892) where it is present apparently as sodium chloride. As is the case with potassium, sodium must often occur only as an excretory product; thus crystals of sodium urate found in the hypodermic cells of water-bugs (*Notonecta*, *Plea* and *Anisops*) are expelled during the moults, this constituting a special method of excretion (Poisson, 1925). Hollande (1914) observed granules of sodium urate in the adipose tissue of the larvae of *Vanessa urticae* and *V. io* at the approach of the nymphal period. He regarded them, however, as reserves, not as excretory products.

Bunge (1874), on comparing the potassium and sodium content of certain Lepidopterous pupae, found that the sodium content of *Pieris brassicae* was three times as high as that of *Pygaera bucephala*; the larva of the former feeds on cabbage, which is a plant very rich in sodium. This means that the sodium content of insects depends on the food.

Magnesium. Magnesium seems to be one of the most universally distributed elements, and its content is often fairly high. Thus, in silkworm eggs over 10% of ash consists of magnesium. As regards the possible physio-

logical rôle of magnesium, Frenzel (1882) considered it as a typical component of the digestive enzymes of insects.

Calcium. Calcium is another element which occurs in insects both commonly and often in very large quantities. Some records, however, are certainly based on the calcium accumulated for excretion in the Malpighian tubes, in the fat-body, or in the skin (Keilin, 1921; Krüger, 1926; Leydig, 1860; G. Müller, 1925; Poulton, 1889; Schütte, 1921, 1921*a*; Mayet, 1896, 1896*a*; Poisson, 1925; Pantel, 1914–1919*b*; see also pp. 291–4). On the other hand, Koehler (1920), who studied spherical crystals of calcium carbonate in the epithelial cells of the middle intestine of the honey-bee and other insects, suggested that they may play some important part in the metabolism, either neutralising acids or activating fermentation processes. Krüger (1926) expressed the opinion that calcium may play some part in the respiration.

Zinc. Zinc was found only by Aronssohn (1911) in bees; by Delezenne (1919) in *Carabus auratus*, which contained 0·181 per mille, and in *Musca domestica* (traces); by Haber (1916) in cockroaches (spectroscopically).

Copper. Muttkowski (1921, 1921*a*, 1921*b*, 1923) made a special study of copper in insects, and found it in considerable quantities in all (34) examined species of insects, both terrestrial and aquatic, representing practically all orders. The universal distribution of copper in insects indicates that it must have an important function, and Muttkowski advanced the hypothesis that it forms the nucleus of a respiratory blood protein, namely a haemocyanin, but the presence of the latter in the insect blood has not been proved.

Other records of copper in insects are scarce; apart from those recorded in the table, there is only one observation by Giunti, who reported finding 3·8 and 4·3 mgr. respectively of copper in 100 gr. of fresh *Anomala vitis* and *Blatta orientalis*.

Boron. The larvae of *Chironomus plumosus* and the beetle *Tenebrio molitor* were examined for boron with positive results according to Bertrand and Agulhon (1913), who stated that boron exists normally in very small quantities in all animals.

Aluminium. Aronssohn (1911) found a considerable percentage of aluminium (0·10 gr. in 4·23 gr. of ash) in the ash of bees. Birge and Juday (1922) determined Fe_2O_3 and Al_2O_3 (together) in aquatic larvae of *Zygoptera* and *Sialis*; Haber (1916) records finding aluminium spectroscopically in the ash of the cockroach.

Silicon. Silicon appears to be a fairly common constituent of the insect body, but its percentage is subject to very marked variations, ranging from 0·57% of the total ash in the silkworm (Lenz, 1867) to 14·90% in the Cantharid beetles (Kübly, 1886). Apart from the data in the table, there is a record by Schütte (1921, 1921*a*), who found silicon in the hard winter cocoon of *Hydromyza livens*.

Titanium. Titanium has been recorded only once from the cockroach (Haber, 1916; spectroscopical analysis).

Lead. Traces of lead were discovered in the blood of several insects by Muttkowski (1923), and he thought that lead is a normal constituent of insect blood.

Phosphorus. Since, apart from the inorganic salts, phosphorus occurs in all organisms as one of the main constituents of nuclein and similar compounds of primary importance, it is not surprising that the phosphorus content of insects is usually very high. Indeed, almost always phosphorus takes the first place amongst other ash elements. In the eggs its quantity is particularly high, reaching in silkworm eggs, for example, 53·8% of the total ash (Péligot,

1852); this egg phosphorus is contained in the yolk, since the "oil" pressed out of locust eggs is very rich in phosphorus (1·92% of total weight in P_2O_5; Dubois, 1894). Frenzel (1882) considers phosphorus as a constant component of the digestive enzymes of insects.

In addition to the data given in the table, there are some scattered records of the occurrence of phosphorus in insects (Davis, 1917; Briones, 1896; Dubois, 1886; Flury, 1920; Fricker, 1885; Glaser and Chapman, 1916; Lacaze-Duthiers et Riche, 1854; Pagnoul, 1895; Pantel, 1919, 1919*a*, 1919*b*; Slowtzoff, 1909).

Arsenic. A very small quantity (0·00000015 gr. in 4·23 gr. of ash) was found in bees by Aronssohn (1911); McIndoo and Demuth (1926) also analysed bees and found that some of them contained as much as 0·0001 mgr. of arsenic per bee, others a trace, and still others none at all. Muttkowski (1923) found traces of arsenic in insect blood, and thought it to be a normal blood constituent. Jarvis (1923) records 0·16% of arsenic in the meal from cane-beetles (*Lepidoderma* spp.); he thinks that the arsenic may have been derived from cane land treated with arsenic against the larvae of the beetles; in any case, it was passed by the larvae through the pupae to the adult beetles.

Sulphur. As a constituent of proteins sulphur is both universally distributed in the insect ash and has a high percentage, though always well below that of phosphorus. Apart from the data recorded in the table, the following special cases are worth mentioning. Dubois (1886) found sulphur in the ash of the elytra and wings of luminous Elaterid beetles. Rudolfs (1927) made a special study of sulphate metabolism in the larva of *Malacosoma americana* (see p. 307). Verson (1884) reported 4·4% of sulphur in the shells of silkworm eggs.

Chlorine. A very high chlorine content was indicated by Griffiths (1892*b*) in the ash of the blood of insects. Brecher (1925) determined the chlorine content of blood of pupae of *Pieris* as 0·1%. Portier et Duval (1927) studied the molecular concentration of blood and its chlorine content in various insects and found that, though the molecular concentration is very high, the chlorine content is low; thus in *Dytiscus marginalis* the chlorine content of the blood was 3·70 gr. of NaCl per 1000, and in larvae of *Cossus cossus* only 0·44 gr.; chlorides represent only a small portion of molecular concentration of the blood, *i.e.* from 4·2 to 30% (in Mammals the figure is 65–70%).

Iodine. Aronssohn (1911) found 0·000009 gr. of total iodine in 4·23 gr. of the ash of bees. Caubel (1898) made special estimations of iodine for a number of insects: the quantities found were small, *e.g.* 0·0025 mgr. to one gram of body-weight in the larva of *Melolontha*, 0·008 mgr. in the adult of the same species, 0·0001 in the larva of the house-fly, etc. Free iodine has been found in the vapour-like secretion emitted by the Javanese beetle *Cerapterus quadrimaculatus* by Loman (1885–87).

Fluorine. Fluorine has been doubtfully recorded from the ash of bees by Aronssohn (1911).

Manganese. Analyses by Bertrand and Medigreceanu (1912, 1913) have shown the presence of manganese in all (of five) species of insects examined in the following quantities: *Gyrinus natator*, 0·702 mgr.; *Pieris brassicae*, 0·248 mgr.; the larva of *Chelonia caja*, 3·248 mgr.; the larva of *Ch. villica*, 1·219 mgr.; *Tettigonia viridissima*, 0·381 mgr. per 100 gr. of fresh substance. Children (1824) reports finding traces of manganese in the ash of *Lytta vesicatoria*, and Dubois (1886) found this element in the ash of the elytra and wings of luminous Elateridae. Other data are given in the table (p. 277).

Iron. Iron is one of the most widely distributed ash constituents, and its percentage is often fairly large. The iron-containing pigments found in many insects are of special interest and importance. The best known is haemoglobin, which was detected many years ago in the larvae of *Chironomus*. Harnish (1925) made a special study of the iron metabolism in the larvae of Chironomidae; and found that resorption of iron results in the formation of granules in the adipose tissue which contain iron; but that its presence is obscured by an organic substance. No increase in the size or number of granules was observed if the larvae were fed on detritus rich in iron. This means that the granules serve not for storing the superfluous iron, but represent the result of a definite metabolic process. The author suggested that the granules may play some part in the gaseous exchange. He has found similar iron-containing granules also in the adipose tissue of *Anopheles* larvae and in those of *Tenebrio molitor*. This suggests that iron may be widely spread in insects. Further data on haemoglobin are given by Comas (1927), Hungerford (1922), Kemnitz (1914, 1917), Rollet (1861), Pause (1918).

Keilin recently (1925) reported the discovery in many insects of a special pigment, cytochrome, consisting of three haemochromogen compounds, two of which have an iron-pyrrol nucleus similar to that of haemoglobin. The pigment has an important function as an intracellular respiratory catalyst. McMunn (1887) described another iron containing pigment, myohaematin, in the muscles of various insects. Linden (1903) has found that the red pigment of *Vanessa* sp. is a protein-containing iron. It may possess a respiratory function, or be a reserve substance.

While all these data are only fragmentary, there can be little doubt that iron plays a very important part in the general metabolism of insects.

Additional analytical data, etc., are given by the following authors : Briones, 1896; Dubois, 1886; Glaser and Chapman, 1916; F. Hopkins, 1896; Landois, 1864; Mayer, 1896; Metalnikoff, 1896; Odier, 1823; Schneider, 1888.

Nickel. Bertrand and Mâcheboeuf (1925) studied the distribution of nickel in animals and plants. Of the insects only silkworms were analysed. A hundred and seventy silkworm pupae (200 gr. fresh weight) were studied, but the presence of nickel was not definitely established.

General Observations. It will be seen from the foregoing that at least nineteen elements are known to enter the body of insects as ash elements, and their actual number is certainly still larger, since no detailed systematic studies in the mineral composition of insects have yet been undertaken, and practically the whole existing knowledge on the subject is based on fragmentary and partly accidental evidence. In view of the well-known influence on metabolic processes exercised by metallic elements, it seems essential in the first instance to obtain a thorough knowledge of the ash elements of the largest possible number of insects of various habits. A series of ash analyses made on a definite plan would give very valuable material for future studies in insect metabolism. In arranging the analyses special attention would require to be paid to the necessity of separating excretory products and ingested food from the actual constituent parts of the insect body. This has never yet been done.

(*b*) Nitrogenous Substances.

Nitrogen Content. There is a fair number of determinations of the total nitrogen content of insects. Fluctuations in the content are, perhaps, more evident during the development of a given species than between various species. Thus the larvae of *Deilephila euphorbiae* contain 1·30–2·62% of the live weight

of nitrogen, the pupae 2·94%, and the adults 4·86–5·34% (Abderhalden, 1923). Similarly, silkworms contain 11·23% of dry weight of nitrogen, their pupae 8·87% and the adult moths 10·49% (Inouye, 1912). Further data on the variation of the nitrogen content during development are given in the section dealing with the metabolism of nitrogen (p. 302). The following are a few further examples of the nitrogen content of various insects :—

Melolontha melolontha, fresh : 3·23, 3·48% (Dingler, 1927); 3·672% (Slowtzoff, 1909).

Melolontha melolontha, dry : 9·57; 12·07; 11·06% (Dingler, 1927); 11–12% (Fricker, 1885); 11·06% (Pagnoul, 1895).

Locusts (*Schistocerca paranensis*), dry : average 11·5% (Künckel d'Herculais, 1899).

Cane-beetles, *Lepidoderma* spp., dry : 10·20% (Jarvis, 1923).

Palingenia laticauda (Ephemerid), dry : 12·08 (Zaitschek, 1904).

Larvae of *Pieris brassicae*, fresh : 1·82–1·90%.

It will be seen from these examples that the average nitrogen content of insects is about 10% of the dry substance, and that the differences as between one species and another are not great. (Further data on the nitrogen content of insects may be found in the following papers : Birge and Juday, 1922; Grandis and Muzio, 1897; Heller, 1925, 1926, 1926*a*; Luciani et Lo Monaco, 1897; Rudolfs, 1926*a*; Parhon, 1909; Péligot, 1865; Pilewiczowna, 1926; Russo, 1921, 1922; Slowtzoff, 1904–1909.)

Proteins. The following are determinations made of the protein percentage in insects (fresh weight) :—

Melolontha melolontha, 17·13% (Slowtzoff, 1909).

Humble-bee, 18·11% (Slowtzoff, 1905*a*).

Libellula cancellata, 13·22% (Slowtzoff, 1905).

It will be seen later, in the section on nitrogen metabolism, that the fluctuations in the protein content during the individual development of an insect are very considerable and probably exceed the differences between one species and another.

No special studies have been made on the various kinds of proteins constituting the bodies of insects.

Amino-acids. Most of the work done on the amino-acids of insects refers to the silkworm, since the silk itself is composed of a number of these acids (see p. 288). Analyses (hydrolysis) of this insect at different stages of development gave the following percentage of various amino-acids :—

	Egg-shells (Tomita, 1921).	Silkworms (Abderhalden u. Dean, 1909).	Moths (Abderhalden u. Weichardt, 1909).
Glycocol	13·72	10·2	3·5
Alanine	3·80	8·7	3·2
Valine	0·28	1·7	1·7
Leucine	1·46	4·8	8·5
Proline	2·17	1·5	4·0
Phenylalanine	0·69	2·4	2·7
Aspartic acid	0·37	1·6	2·7
Glutamic acid	4·16	3·5	5·7
Serine	1·10	—	—
Tyrosine	11·19	4·3	1·6
Arginine	0·19	—	—
Histidine	Present	—	—
Lysine	0·39	—	—

Tryptophane in insects was studied also in silkworm by Demianowsky (1928), who has found that the tryptophane content of silk increased inversely with the conditions of nutrition of the worms; diseased, or weak, worms formed cocoons with a larger percentage of tryptophane. Jezewska (1926) made some estimations of tryptophane content of the pupae of *Musca vomitoria*, and found that an increase in tryptophane content occurs on about the fourth day after pupation.

Other amino-acids definitely recorded from insects are leucine (*Melolontha melolontha*, Ackerman, 1920; Kutcher u. Ackermann, 1926; fluid emitted by moths of *Sphinx pinastri* on emergence, and pupal casts of *Cossus cossus*, Schwarzenbach, 1856; indoloid smelling secretion of ants *Eciton*, Melander and Brues, 1906); putrescine and lysine (both from *Melolontha melolontha*, Ackerman, 1920; Kutcher u. Ackermann, 1926); arginine (*Melolontha melolontha*, Kutcher u. Ackermann, 1926). Leucine has been recorded definitely as an excretory product from the Malpighian tubes and from excreta of some insects (Marchal, 1889; Sinety, 1901; Veneziani, 1905).

Other Nitrogenous Compounds. A good deal of data exists on the nitrogenous compounds derived from purine, particularly on the uric acid and urates. These are, however, found almost exclusively in the Malpighian tubes or in the fat-body. They represent final products of metabolism temporarily stored for excretion. Much data relating to these substances have been derived from analyses of excreta. The following is a list of references :—

Uric acid: Ackerman, 1920; Audoin, 1836; Blochmann, 1888; Carlier and Evans, 1911; Chaussier, 1783; Griffiths, 1888; Heller, 1844; F. Hopkins, 1889, 1896; Karsten, 1848; Kawase and Suda, 1921; Krukenberg, 1880; Kutcher u. Ackermann, 1926; Marchal, 1889; Gorka, 1914; Seguin, 1859, 1860; Sinety, 1901; Sirodot, 1858; Stuhlmann, 1907; Roubaud, 1922*a*, 1923; Wurzer, 1818.

Urates: Brugnatelli, 1815; Cuenot, 1896; Fabre, 1863; Faussek, 1911; Gerstaecker, 1873; Gorka, 1914; Hollande, 1909, 1914, 1925; Korschelt, 1924; Krukenberg, 1880; Maillot et Lambert, 1902; Marchal, 1889; Metchnikoff, 1915; Pantel, 1919*a*; Perez, 1902, 1910; Philiptchenko, 1906, 1907, 1907*a*; Plateau, 1873; Poisson, 1925; Roubaud, 1913, 1922*a*, 1923; Samson, 1908; Schmieder, 1928; Schulz, 1925; Schwarzenbach, 1856; Seguin, 1860; Sirodot, 1858; Sinéty, 1901; Struve, 1873; Veneziani, 1905; Verson, 1911.

Further data on uric acid and urates specially in excreta are given on p. 292, and the literature on these substances and their derivatives used in the pigments of insects is reviewed on p. 287.

Urea (carbamide) was doubtfully recorded from insects by Marchal (1889) and Sirodot (1858) and more definitely by Veneziani (1905), while Fosse (1913) found it in the cellular fluid of silkworm and in the eggs of ants-flies, apparently as an intermediate metabolic product.

Hypoxanthine, adenine, guanine and avertebrine were detected in *Melolontha melolontha* as extractive substances (Ackerman, 1920; Kutcher u. Ackermann, 1926).

Amongst other substances, less frequently met with, of which there is little knowledge at present, may be mentioned mycomelic acid (F. Hopkins, 1889), lepidopteric acid (Griffiths, 1892*a*), leucopterine (Schöpf u. Wieland, 1926), lithic acid (Davy, 1846; Tulk, 1843), hippuric acid (Marchal, 1889).

Finally, there is a series of various nitrogen-containing substances in the integuments of insects to which very little study has been given. Thus, the shells of silkworm eggs consist not of chitin, but of chorionin containing nitrogen and sulphur, apart from hydrogen and oxygen (Verson, 1884; Tichomiroff,

1885; Farkas, 1903*a*). Griffiths (1892) described briefly a substance which he named pupine, extracted from the pupal skins of various Lepidoptera. Aronssohn (1910) analysed larval skins of honey-bee larvae and found that they consisted of a peculiar substance containing 10·7% of nitrogen and no sulphur, which was not referable to any known group of organic compounds. Fink (1927) has published some data on glutathione in insects.

(*c*) Fats and Allied Substances.

Owing to the development, which is often very great, of the so-called fat-body (which is an organ for accumulating reserves and partly also the excretory substances), the fat content of insects may reach very high figures, as will be seen from the following examples :—

Silkworms, 17·78%; their pupae, 43·45%; moths, 24·21% (Inouye, 1912).

Larvae of *Gastrophilus equi*, from 14·7 to 21·3% (Kemnitz, 1917).

Bee-larvae, from 4 to 21·3% (Strauss, 1911).

Dry *Melolontha melolontha*, from 10% (Fricker, 1885) to 11·5% (Dingler, 1927).

It will be seen later (see p. 304) that the fat content is subject to very great fluctuations during the individual development of an insect. It is particularly high in the resting (pupal) stage.

The fat-body of insects has been subjected to numerous and very detailed studies from the morphological and histological point of view, but the fat itself has hardly been studied at all chemically. There are only a few scattered data available. Huerre (1911) studied the fat of cochineal and detected in it oleic, linoleic and myristic acids; C. Liebermann described the same fat (1885). Rocci (1915, 1916) stated that the fat of moths of the genera *Zygaena* and *Ino* does not present any special differences from other known fats in its chemical properties, and that in some respects it approaches rather vegetable fats than the animal ones. Timon-David has recently published several very interesting studies (1927, 1927*a*, 1928) on insect fats, from which it is evident that the problem is complicated and that any generalisations may be dangerous. He proved, for instance, that the iodine index of fats of different insects varies from 37·3 to 112; and that two xylophagous larvae (*i.e.* those of *Oryctes nasicornis* and of *Ergates faber*) produce fats with very different properties. His study (1928) of the fat of Aphids *Pemphigus utricularius* and *P. cornicularius* living on *Pistacia terebinthus* showed that it is very rich in acids belonging to the lower group of saturated acids which makes this fat very different from other insect fats. The Japanese authors Kawasa, Suda and Fukusawa (1921) studied the "chrysalis oil," *i.e.* the fat pressed out of the pupae of silkworms; they found that the mixed fatty acids of the oil contain about 25% solid and 75% liquid acids; the solid acids include the palmitic and isopalmitic acids. (Further data on insect fats are given by Rabow, 1916; Raimann, 1886; Briones, 1896; Lewkowitch, 1906, 1907, 1914; Welsh, 1909; Dubois, 1894, 1924.).

Wax will be discussed later amongst other secretions (see p. 289); but it would be convenient to mention here that Hollande (1914*a*) made a special study of the so-called oenocytes, or cerodecytes, metamerically disposed specialised cells which contain wax apparently as a reserve substance or an intermediate metabolic product, not as a secretion.

Cholesterine has been recorded in the extract from beetles *Melolontha melolontha* (Ackerman, 1920); in chrysalis oil (Lewkowitch, 1907); in the yolk of hibernating silkworm eggs (Tichomiroff, 1885). Menozzi and Moreschi

(1908, 1910) discovered in the fat extracted by ether from dry silkworms a substance (which they named bombycesterine) which belongs to the cholesterine group, but differs in some of its properties from cholesterine and is perhaps its isomer.

Lecithine was recorded by Tichomiroff (1885) in the yolk of hibernating silkworm eggs.

Choline, glycerine, palmitic acid and non-saturated fatty acids were found by Flury (1920) in the bee poison; Ackerman (1920) records choline amongst the extractive substances of *Melolontha melolontha*.

(*d*) Carbohydrates.

The literature on carbohydrates in the insect body is remarkable for its scantiness. Only scattered data exist on the few main substances of this group.

Glycogen. Glycogen is apparently universally distributed in insects, but its metabolic rôle and importance are not yet fully appreciated (Snodgrass, 1925). Generally speaking, it is a reserve substance and it accumulates mainly in the cells of the fat body and is utilised in the course of metamorphosis. The total glycogen content of insect larvae may reach very high figures; thus, the larva of *Gastrophilus equi* contains up to 31·1% of glycogen (Kemnitz, 1914); and in the larva of the honey-bee the glycogen content increases towards the end of the larval period to 33·48% of the dry weight of the larva (Straus, 1911). Adult insects seem, however, to contain little glycogen. In adult bees the amount varies from 0·14 to 0·21% of body-weight (Parhon, 1909). Chemical characterisation of insect glycogen has been made by Anderlini (1887). Additional information on glycogen is contained in papers by Hollande (1914*a*), Kaneko (1924), Philiptchenko (1907), and Vaney et Maignon (1905, 1907). For the metabolism of glycogen see p. 306.

Glucose. Glucose has been determined in the pupae of silkworm only towards the end of the pupal period, no trace of it having been found in young pupae; it is always present in adults, according to investigations by Maignon (1903). For the metabolism of glucose see p. 307.

Sugar in the Blood of insects has attracted the attention of only two investigators. Hemmingsen (1924) made some determinations of blood-sugar in various Lepidopterous larvae and found that the sugar content varied from 0·018 to 0·040%. Blumenthal (1927) published the following preliminary estimations of blood-sugar of several insects (in mgr. per 100 c.c.):—

	Average.	Range.
Orthoptera.		
Rhomalea microptera	41·7	34·2–49·4
Melanoplus femur-rubrum	35·3	30·6–41·9
,, *differentialis*	36·5	31·0–45·9
Chorthophaga viridifasciata	34·0	32·8–35·2
Encoptolophus sordidus	36·4	
Coleoptera.		
Popillia japonica (larvae)	63·0	56·3–69·2

Blumenthal considers that these data suggest that species which are taxonomically related may have blood-sugars which are quantitatively similar.

Chitin. Chitin forms all the outer integuments of insects. It was discovered first by Odier (1823), who, however, did not find any nitrogen in it. This mistake was corrected by Children (1824), who made a qualitative determination of C, H, N and O in chitin. Bütschli (1874) suggested that chitin is

a derivative of a carbohydrate. Detailed studies on chitin were undertaken by Krawkow (1892), who studied the reactions of chitin of various insects. He came to the conclusion that there are several kinds of chitin which differ from one another by the iodine reaction; and that the affinities of animals are reflected in the similarity of their chitin. Krawkow's view on the chemical nature of chitins was that they are amino-derivatives of carbohydrates, and that in the chitinous structures the chitin is loosely connected with protein substances. The metabolic rôle of chitin is obscure, and no work has been done in that direction (see also Bounoure, 1912).

Cantharidin. Numerous chemical and especially pharmaceutical studies have been made on cantharidin (the most recent papers are those by Dankworth, 1914; Gadamer, 1914, and Fredericq, 1910). No attempt, however, has been made to connect its presence in certain insects with metabolic processes.

(*e*) Pigments.

The pigments of insects belong to several groups of very different chemical character. It would have been possible to include them under the corresponding headings, but it seems preferable to review them together in the present section. The classification of pigments adopted is that by Verne (1926). Biedermann (1914) and Prochnow (1926) have also written papers on the general question of pigments.

Pigments without Nitrogen in their Chromogenic Nucleus. To this group belong a number of widely distributed pigments. In the first place there are carotins and carotinoids, yellow or reddish-yellow pigments of many insects (Coccinellidae, *Pyrrhocoris*, *Lina*) and of their haemolymph. These pigments are derived from food, *i.e.* from plant carotins, or, in the case of carnivorous insects, from the haemolymph of their prey (*Perillus bioculatus*, Knight, 1924; Palmer and Knight, 1924, 1924*a*). According to Schulze (1913, 1914) carotinoid pigment in the elytra of the beetle *Melasoma populi* is present in crystals included in the cells of a special tissue, but Kremer (1914) believes that this tissue is the ordinary fat-body; in any case the pigment represents probably a reserve material. (See also Phisalix, 1894; Dubois, 1890.)

The pigments of Coccidae also belong to this group. The best known is the red pigment of cochineal, which consists of carminic acid (Perkin and Everest, 1918; Meyer, 1891), possibly in the form of a potassium salt in the adipose tissue of the insect (Verne, 1926). The pigment of *Lecanium ilicis*, the kermes dye, is kermesic acid, which is allied to the carminic (Perkin and Everest, 1918; Verne, 1926). The red lac dye or erythrolaccin (Tschirsch, 1900), although formed in the body of the lac-insect, may be a product of symbiotic bacteria (Tschirsch, 1922; see also Perkin and Everest, 1918). The physiological rôle of the pigments of Coccidae is not known.

Not all the red colours of insects are due to carotins, and some water-soluble pigments appear to be even more common than carotins. Thus the Aphid *Tritogenaphis rudbeckiae* owes its vermilion colour chiefly to an anthocyanin-like pigment (Palmer and Knight, 1924*a*). Another Aphid, *Pterocomma smithiae*, also contains a red pigment localised in fat-body cells and similar in its reactions to anthocyanins (Glaser, 1917). The larvae of the beetle *Cionus olens* feeding on the stamina of *Verbascum nigrum* contain in their adipose tissue granules of the same anthocyanin as that contained in the stamina (Hollande, 1913). It is not clear whether in all these cases the pigments should be regarded as reserve materials.

Pigments of the flavone group have also been found in insects. Palmer and Knight (1924*a*) have discovered flavone-like red pigments in several Hemiptera; and Thomson (1926) has isolated from the wings of *Melanargia galathea* a yellow pigment belonging to the flavones, or flavonoles, which he subsequently (1926*a*) discovered in the food-plant of the larva of that butterfly, *i.e.* the grass *Dactylis glomerata*. It may be presumed that flavone-like pigments are directly derived from food and are not synthetised by insects, though generalisations of this kind should be avoided.

Lipochromes and Carotin-albumins. Hollande (1907, 1909) has discovered in the blood of a number of beetles a yellow pigment which is a special lipochrome, called by the author zoonerythrine. Another lipochrome-like pigment was described by the same author (1914*a*) as occurring in the oenocytes (special cells of the fat-body) of various insects and derived from food. Schulz (1922) studied the red pigment of the blood of the Woolly Aphis and proved it to be a lipochrome. Griffiths (1897) described the red pigment of the elytra of several beetles, which he called coleopterine and classified as a lipochrome. Toumanoff (1928) stated that lipochromes in the stick-insect *Dixippus* (*Carausius*) *morosus* are derived from the chlorophyll in food.

The pigments which Abeloos and Toumanoff (1926) classified as carotinalbumines are more complicated. To this section belongs the pink-purplish pigment at the base of the front femora of the female of *Carausius morosus*. Apparently a similar pigment is responsible for the pink coloration of sexually immature locusts (*Scistocerca gregaria*); some of the green coloration is also due to a carotinalbumin.

Pigments with Tetrapyrrolic Nucleus. Haemoglobin, cytochrome, myohaematin and the red pigment of *Vanessa* belong to this group. For the literature on them see p. 281.

Pigments with other Metallic Groups. In this section belong, first of all, the chlorophylls, on the existence of which in insects there is a considerable literature and a good deal of controversy. It would be out of place on the present occasion to enter into a detailed discussion of the problem which is still very insufficiently studied from the chemical point of view, since most of the positive proofs of the presence of chlorophyl in insects are based on mere colour or on spectroscopic data. The actual state of existing knowledge may be summarised as follows: there is no doubt that chlorophyll derived from food-plants occurs in insects; but it must not be assumed that all cases of green coloration are due to chlorophyll, or even to its derivatives. Unfortunately no data exist on the possible rôle of chlorophyll in the metabolism of insects, and this is a very great gap in existing knowledge, considering the almost universal presence of chlorophyll in the food of phytophagous insects. Further studies on insect chlorophyll and on the fate of chlorophyll ingested with food are urgently needed. A full bibliography on insect chlorophylls is not given, since the bulk of it does not deal with the chemical aspect of the question; the main papers are those by Poulton, 1894; Przibram, 1913; Toumanoff, 1928 (see also Verne, 1926).

Another pigment of this group is haemocyanin, the presence of which in insect blood has been suggested by Muttkowski (1921, 1921*a*, 1921*b*, 1923), but not proved (see also p. 279).

Pigments of Protein Origin. To this group belong melanins, which are widely spread in insects. It is not proposed to consider them here, since they can scarcely have any relation to nutritional problems. Moreover, existing knowledge of the chemistry of melanines is very restricted.

Pigments with Purine Bases. Hopkins was the first to draw attention to

the fact that certain white and yellow pigments of the scales of butterfly wings are actually excretory products, namely uric acid and its allies (Hopkins, 1889, 1889*a*, 1896). Griffiths (1892*a*) described the green pigment in the wings of some Lepidoptera as a derivative of uric acid, under the name lepidopteric acid, while another brown pigment, called by him cupreine and apparently also derived from uric acid, has been found by the same author in the elytra of beetles (Griffiths, 1895). Urech (1894) made extensive studies in the pigments of Lepidoptera which showed that generally speaking the pigments belong to the group of uric acid and allied groups, as well as to the products of the decomposition of proteins; definite proofs of the uric acid itself were obtained only in Pieridae. Wigglesworth (1925) undertook quantitative determination of uric acid in *Pieris brassicae*. Schöpf and Wieland (1926) analysed the white pigment of the scales of Pieridae more exactly and found that it is not uric acid, but a special compound, leucopterine, allied to uric acid; the same authors (Wieland and Schöpf, 1926) examined also the yellow pigment of the wings of *Gonepteryx rhamni* and found it to be a new compound, xanthopterine, derived from purine. They proposed the name lepidopterines for all pigments in wings of Lepidoptera.

The most interesting point about this group of pigments is that they are clearly the final products of metabolism transferred to certain parts of the integuments, and deposited there instead of being excreted. Their physiological rôle, therefore, is very different from that of all other pigments.

Finally, reference should be made to Geyer's (1913) discovery, of the remarkable dimorphism in the pigmentation of the blood of various Lepidoptera; in the females pigments derived from chlorophyll were usually found, but in the males there was either xanthopyll or no pigment at all. This was observed only in phytophagous insects. The cause of this phenomenon remains obscure, and no one else has attempted to solve the problem.

(*f*) Secretions.

The somewhat vague term " secretions " is usually applied to a considerable number of substances which are given out by insects from special glands and in most cases serve, or appear to serve, some special biological purpose, *e.g.* defence against enemies, preparation of cocoon, etc. These more obvious functions of secretions tend to obscure their metabolic significance, and most investigators have been tempted to study secretions as phenomena quite apart from the " normal " physiology of insects. It will be seen from the following survey of the literature that this point of view is erroneous, and that secreted substances must always have a very direct relation to the general metabolic processes in the organism.

Some insect secretions have been very carefully studied owing to their commercial importance; under this heading come silk, beeswax, and lac; but the bulk of the literature dealing with them is not relevant to the present review, since it concerns the technical properties of the products themselves without any relation to the insects producing them. In accordance with the plan of the present paper, only the most important literature dealing with insect secretions from a physiological point of view is reviewed in the following sections.

Silk. Silk is produced in special glands by the larvae of many Lepidoptera (and a few other insects), but the silk of the silkworm (*Bombyx mori*, L.) is naturally the kind which has been most carefully studied. An enormous literature exists on the composition of different varieties of silk (good reviews of it

from a physiological point of view may be found in Fredericq, 1910; Fürth, 1903, and other textbooks of biochemistry). Hydrolysis of silk shows it to consist of a number of amino-acids, amongst which Abderhalden (1922) separated the following: arginine, 1·5 gr. in 100 gr. of fibroin (solid fraction of silk); lysine, 0·85; histidine, 0·75; glycocol, 40·5; *d*-alanine, 25; *l*-leucine, 2·5; phenylalanine, 1·5; *l*-serine, 1·8; *l*-proline, 1·0; *l*-tyrosine, 11; the total was 86·4 gr., the difference being due to loss. The composition of different varieties of silk differs considerably; thus Tussur silk contains glycine, alanine, leucine, aspartic acid, glutamic acid, serine, proline, hydroxyproline, phenylalanine, tyrosine (Inouye, Iwaoka and Hirasawa, 1920); see also Abderhalden u. Dean, 1909; Abderhalden u. Inouye, 1912). The sericine of the silk, *i.e.* the portion soluble in water, has been recently analysed by Alders (1927), who obtained the following main results: total ash, 3·9; tryptophane, 1%; tyrosine, 6·0%; cystine, 1·2%; arginine, 4·3%; histidine, doubtful; lysine, 0·7%. In addition to these amino-acids, tryptophane was found in silk fibroin by Hiratsuka (1925; see also Demianowsky, 1928).

The physiology of silk production remains still insufficiently studied from the point of view of metabolism. Indeed, the physiological necessity for the production of such enormous amounts of amino-acids is far from clear. The problem could be studied, perhaps, more profitably on other Lepidopterous larvae than on the cultivated silkworm, whose organism is obviously highly modified by breeding and selection. Theoretically, it would be of great interest to see the effect on the silk production of feeding with substances not producing amino-acids. Experiments with silkworms offered leaves of mulberry sprayed with a solution of amino-acids showed an increase in the output of silk (Kazancev, 1912). This seems to indicate that silk production is, at least partly, a means of eliminating superfluous amino-acids from the organism, and the utilisation of silk for building the cocoon is a secondary adaptation (see also Pigorini, 1915).

Wax. The secretion of wax is known in a large number of insects of various Orders. Of these beeswax has naturally been the best studied, though practically the whole literature on it refers to the technical and chemical properties of various kinds of wax, and relatively very little is known on the physiology of wax production by bees.

Beeswax is secreted from special glands on the abdominal segments. It consists chiefly of a mixture of crude cerotic acid and myricin; it also contains, in small quantities, free melissic acid, myricyl alcohol, another alcohol of unknown composition, some cholesterin esters, small quantities of unsaturated fatty acids, and some hydrocarbons (Lewkowitch, 1914). Margarinic acid was found in wax by Kablukov and Girschberg. From the physiological point of view, beeswax must be regarded as an end-product of the biochemical metabolic processes in the bee organism. According to G. Buchner (1918) the formation of wax is probably an anoxybiotic process of synthesis from carbohydrates or from products of their deterioration; probably some enzymes take part in the process (see also Eckert, 1922; Dumas et Milne Edwards, 1844; Fredericq, 1910; Fürth, 1903).

Wax secretion in various insects was studied by Dusham (1918), but only from a histological point of view. Hollande (1914*a*) pointed out the presence of wax crystals in oenocytes, or cerodecytes, of the fat-body; this indicates that wax plays a definite part in the general metabolism of insects, and its external secretion may be due merely to an excessive production.

The wax of bumble-bees was studied by Sundwick (1898), who also analysed

the wax of *Psylla* (1901). The wax of Brazilian bees, *Trigona*, was analysed by Gadamer (1917). For analyses and properties of other waxes see Lewkowitch, 1914; Fredericq, 1910; Fürth, 1903; Piaggio, 1922; Sestini, 1866.

The wax of the Woolly Aphis, according to Schulz (1922), is not a wax in the chemical sense, but a glyceride of a fatty acid.

Lac. Lac is a secretion of the epidermis of the lac-insect (*Tachardia lacca*) and it consists of three kinds of substance—the lac, *i.e.* a mixture of resinous substances and wax; lac-dye, *i.e.* pigment, or pigments; and honey-dew, *i.e.* the insect's sugary excretions. The pure lac has as its main component parts laccaic acid and aleuritic acid (Tschirsch, 1900; Tschirsch u. Lüdy, 1923). The composition of lac depends to a considerable extent on the food-plant, but the physiology of the lac-insect and the processes which lead to the transformation of the plant sap into various components of lac have never been studied, in spite of the great economic importance of the lac industry. (Main literature on lac, apart from the purely industrial: Gascard, 1893; Imms and Chatterdjee, 1915; Lindsay and Harlow, 1921; Stebbing, 1910; Tschirsch, 1900, 1922; Tschirsch u. Lüdy, 1923; Farner, 1899; Watt, 1901; Perkin and Everest, 1918; Fredericq, 1910.)

Poisonous Secretions and Poisonous Insects. The poison of bees and other stinging insects is usually regarded from the point of view of its possible importance to the insect as a means of defence against enemies, no attention whatever being paid to its rôle in the organism of the insect itself. It is, therefore, very refreshing to see that one of the best authorities on animal poisons, Strohl (1925), advanced the view that animal poisons are merely side products of metabolism, in which they may play a very important part. In other words, although poisons may be used for defence, they are not specially prepared for that purpose, but are normal metabolic products. Unfortunately, the actual study of insect poisons from this point of view is a problem for the future, and the existing data are very scanty. (Strohl, in the paper referred to above, presents a very good review of the subject, with a bibliography; see also Pavlovsky, 1927; Fredericq, 1910; Fürth, 1903; Rocci, 1915*a*, 1916–1917*a*.)

Flury (1920) made a detailed study of bee-poison obtained from more than 200,000 living bees, and found that the protein-free substance which can be isolated from the poison is a very complex compound. A considerable part of it is a lipoid, but the following substances also enter into its composition, viz. a derivative of the indole series, choline, glycerine, phosphoric acid, palmitic acid, non-saturated fatty acid, apparently butyric acid, and a nitrogen-free portion, which is the pharmacologically active substance.

A considerable pharmacological and chemical literature exists on the arrow-poison extracted by South African bushmen from the larvae of the beetle *Diamphidia locusta*, but from the physiological point of view the data are not important (Kolbe, 1894; Lewin, 1894, 1912).

Formic Acid. Formic acid as a secretion of ants was first mentioned in the literature more than 250 years ago (Wray, 1671), but its physiological rôle is still obscure. Indeed, no attempt has ever been made to attack the problem from this point of view. (For the main literature on formic acid see the following papers: Melander and Brues, 1906; Stumper, 1921, 1922; Fürth, 1903; Kobert, 1903; Fredericq, 1910.) Meldola (1895) recorded formic acid in the secretion of the larva of *Dicranura vinula*.

Salicylic Acid. Insects feeding on willows and *Populus*, the leaves of which contain a glucoside salicin, have developed special means of eliminating it from the organism in addition to the excretory system. This is done by special

reversible glands in the case of *Melasoma* and *Plagiodera* (Hollande, 1909*a*). In the beetle *Aromia moschata* there is a pair of coxal glands which also serve this purpose (Smirnov, 1911). The last-named author fed *Aromia* on syrup and found that the secretion of glands did not contain the salicylic acid which is present in the normal secretion. This proves that the glands have really an excretory function (see also Claus, 1862; Weber, 1899).

Other Secretions. The mandibular glands of the larva of *Cossus cossus* secrete an essential oil constituted of 77·61% of carbon, 11·01% of hydrogen, and 10·00% of sulphur; it is probably extracted directly from the sap of the food-plant (Henseval, 1897). In other words, this is, perhaps, another example of the secretion of superfluous substance, or more properly of an excretion. According to Denham (1888) the caterpillars of *Notodonta concinna* secrete strong hydrochloric acid; but the observation has not been repeated by any later worker. Butyric acid has been reported by Pelouze (1856) in the secretion of the abdominal glands of *Carabus*. This again may be a case of excretion. Free iodine was found by Loman (1885–1887) in the secretion of rectal glands of a Javanese beetle *Cerapterus quadrimaculatus*, Westw. Melander and Brues (1906) reviewed the literature on the odorous secretions of insects. The chemical nature of these secretions (apart from the formic acid, see above) is, however, unknown, and it is therefore impossible to discuss the physiological rôle which they play.

(*g*) Excretions.

Excretions are those substances which are given out by insects or accumulated in their excretory organs, and which are clearly not intended to play any further rôle in the metabolism of the insect, though some of them may be of certain biological importance (*e.g.* as material for building cocoons, etc.). Here belong the excrements, both solid and liquid, and the substances accumulated in the fat-body and the Malpighian tubes. It has already been shown (see pp. 286, 288) that a very considerable number of substances usually classified as secretions as well as some pigments should be really regarded as excretions, since they clearly represent final products of metabolism, and are eliminated from the organism.

Hardly any of the papers dealing with the chemical constitution of insect excreta make any attempt to connect the constitution of excreta with that of the food taken by the insect. It is, however, clear that the most valuable work on excreta would be the collection of data for the solution of the question regarding which elements of a particular food are utilized by the insect studied and which are eliminated. Apparently the only author who attacked the problem from this point of view is Péligot (1852, 1865, 1867), who analysed mulberry leaves, silkworms and their excreta. The following table may serve as an example of his results:—

	Leaves.	Excreta.	Larvae
Carbon	43·73	42·40	48·10
Hydrogen	5·91	5·75	7·40
Nitrogen	3·42	2·35	4·00
Oxygen	35·44	26·14	26·20
Mineral substances	11·60	13·80	9·40
	100·00	100·00	100·00

These data are of direct interest to the present purpose only as regards the nitrogen and ash balance, since the balance of oxygen, hydrogen and carbon is, perhaps, more dependent on the respiratory metabolism than on the nutritional. The data are discussed under the following sectional headings.

Nitrogen and Nitrogenous Substances. The analyses by Péligot given above show that a considerable portion of nitrogen in the food is assimilated and that only part of it is excreted. Similar determinations of the total nitrogen in mulberry leaves and in the silkworm excreta were made by Luciani e Lo Monaco (1897), who found that 37·69% of the total nitrogen in the leaves is excreted and 62·31% is assimilated. Grandis e Muzio (1897) studied the assimilation of nitrogen in the larvae of a beetle *Callidium sanguinipes* living in the cambium of oak twigs. The larvae contain, on the average, 4·637% of nitrogen, but the tissue they feed on contains only 0·49% of it, and of that quantity 0·351% is found in the excreta.

The excreta of the larvae of the clothes moth, which feed chiefly on the keratin of hairs, were analysed by Babcock (1912) and found to contain 26·66% of nitrogen, of which 10·22% was voided as ammonia, 47·29% as uric acid, 17·57% as urea, 10% as creatin and creatinine, 0·51% as purine bases, 11·64% being insoluble in HCl and NaOH.

Hollande et Cordebard (1926) also analysed the excreta of the clothes-moth larva with the following result:—

	%
Oxypurine derivatives	28·00
Urea	0·40
Ammonia	3·00
Other nitrogen	7·70
Soluble mineral salts	5·50
Water	1·00
Insoluble	18·00
Undetermined	36·40
	100·00

The authors conclude that the utilisation of the nitrogen of the hair by larvae seems to be very considerable.

The main form in which nitrogen is excreted is undoubtedly uric acid and its salts, the principal literature on which has already been quoted (see p. 283). The same substances or others nearly allied to them are often deposited as pigments, this representing a special form of excretion (see p. 287).

Weinland (1906*a*, 1907, 1908, 1909, 1910), in his experiments on the larvae of *Calliphora*, discovered that they are able to give out ammonia and an amine, the bulk being given out in a gaseous form. The amount of nitrogen given off in this way can be very large, since in some cases 0·85–1·3% of the initial weight of the larva were given off in twenty-four hours. In the pupal stage no ammonia is given off, so that this is a process dependent on the larva feeding on meat. Bogdanow (1908) maintained that ammonia in this case is produced not by the larvae but by the bacteria liquefying meat, since no ammonia could be observed if the larvae were placed on sterilised meat.

Leucine and hippuric acid are recorded in insect excreta by Plateau (1873). The latter substance was also noted by Davy (1854).

Ash Elements. The following is an interesting complete analysis of the ash elements in mulberry leaves, silkworms and their excreta given by Péligot (1852):—

	Leaves.	Excreta.	Larvae.
Silicon	17·6	20·0	3·9
Carbonic acid	18·6	18·0	10·5
Phosphoric acid	10·3	7·6	29·0
Sulphuric acid	1·6	Traces	1·9
Chlorine	0·8	1·2	1·1
Ferrous oxide	0·6	0·7	Traces
Calcium	26·2	29·5	8·3
Magnesium	5·8	6·0	9·3
Potassium	18·5	17·0	36·0
	100·0	100·0	100·0

The figures demonstrate clearly that while some of the ash elements are very thoroughly eliminated, others are accumulated in the organism. The insect has, for example, to ingest a clearly superfluous amount of calcium, in order to obtain sufficient phosphorus for building its tissues. According to Péligot, the total ash in larvae constitutes about 9–11% when they are young, but is reduced gradually to about 4% at the time of pupation, and is then very rich in magnesium phosphate but contains less potassium than before. This is in accordance with the greater mineral content of excreta at this stage, and also with the excretion of the alkaline fluid ejected by the larva when beginning to spin its cocoon. Pupae contain 7–8% of ash, but a large quantity of mineral salts are ejected with the fluid emitted by the moths on their emergence. Some ash, viz. 1·2% of the whole, is given out also in the silk.

Another example of a complete analysis of excreta is offered by Schübel (1912), who analysed stalactites built by the termites *Eutermes monoceros* from their excreta (mixed, apparently, also with sand, etc.). The food of the termites consisted of algae and lichens (no analysis of food is given), and the main constituent part of the excreta was a hydrocarbon with the formula, $C_{35}H_{70}$, while the ash elements included silicon, 45·20; phosphoric acid, 1·09; iron and aluminium, 23·49; manganese, 1·05; calcium, 14·25; magnesium, 1·51; potassium and sodium, 13·29. All the above figures are per cent. of total ash.

The outstanding rôle of *calcium* in insect excreta has already been mentioned (p. 279). In the majority of cases, calcium is eliminated through the Malpighian tubes as calcium carbonate. (Bordas, 1908, recorded calcium carbonate in the Malpighian tubes of cockroaches, but Hallez, 1909, pointed out that this is an oxalate, not a carbonate. For further records see Pantel, 1914, 1919, 1919*a*, 1919*b*; Schütte, 1921, 1921*a*; Plateau, 1873; Vaney, 1900, 1901; Veneziani, 1905; Poulton, 1889; Schumacher, 1921; Batelli, 1879; Eastham, 1924; G. Müller, 1925.) Calcium carbonate is either eliminated gradually, or is accumulated in the tubes of the larva and is expelled only on the emergence of the adult insect, or at the pupation, when it is often used for building a cocoon (Graber, 1890; Friedrichs, 1919). Mayet (1896) describes an analogous arrangement in the larva of *Cerambyx*, which makes out of calcium carbonate a stopper to close its burrow in a tree before the pupation. Another instance of the varied uses to which calcium carbonate excreta may be put is offered by the larvae of Cerocoma, which prepare for themselves shells out of this salt

(Maki, 1914; Ratte, 1884). Still another method of eliminating calcium carbonate is to deposit it in the integument, which is thereby strengthened; this is particularly the case in the STRATIOMYIDAE. In the full-grown larva, for example, of *Sargus cuprarius* living in cow dung, calcium carbonate deposited in the skin constitutes 18% of the dry weight of the whole body, and 75·9% of the dry weight of the skin (Müller, 1925; also Vaney, 1907). The fly *Hydromyza livens* deposits its calcium carbonate in the walls of the winter puparium (Schütte, 1921, 1921*a*). Pantel (1919) observed that organic compounds of calcium in the developing eggs of PHASMIDAE produce calcium carbonate, which is deposited in the shell.

Another common salt in which calcium is eliminated is calcium oxalate. In the case of the larvae of *Chaerocampa elpenor*, feeding on plants containing crystals (rhaphidia) of calcium oxalate, this salt is abundant in the excreta (Netolitzky, 1922). Other records refer to the presence of calcium oxalate mainly in the Malpighian tubes (Sirodot, 1858; Verson, 1890, 1911; Hallez, 1909; Gorka, 1914; Schlossberger, 1857; Plateau, 1873; Veneziani, 1905), but also in the fat-body (Henneguy, 1897; Maillot et Lambert, 1905).

Calcium is also not infrequently eliminated in the form of phosphates (Plateau, 1873; Davy, 1846; Brugnatelli, 1815; Veneziani, 1905; Pantel, 1919, 1919*a*, 1919*b*). Calcium urates are also known as excretory products (Plateau, 1873; Veneziani, 1905).

Potassium is another element commonly found in insect excreta, particularly in the fluid emitted by emerging adults of Lepidoptera, where it is found as a carbonate (Urech, 1890; Verson, 1890), or as caustic potash (Latter, 1892, 1895, 1897; Meldola, 1895). Potassium carbonate is also excreted by the pupating larva of *Saturnia* sp. (Urech, 1890). Other records of potassium are given by Plateau (1873), Veneziani (1905) and Porta (1900).

Magnesium has been recorded in insect excreta by Batelli (1879) as a carbonate, and by Brugnatelli (1815) and also by Urech (1898) as a phosphate.

The excretion of *silicon* has been specially studied by Urech (1896, 1898) on the larva of *Vanessa urticae* feeding on nettles; his analyses of nettle leaves and of the excreta of the larvae showed that the percentage of silicates in the excreta (7·44%) was constantly higher than in the leaves (4·38%). This is the result of the assimilation of certain constituent parts of the leaves by the larvae. No trace of silicon could be found in the larval and pupal skins.

Titschak (1922) studied the excretion of *sulphur* by the larvae of the clothes moth (*Tineola biselliella*) and found that they feed on hairs containing 2·23–2·58% of sulphur. The excreta, however, contained 4·03–4·62% of sulphur. This means that the sulphur in keratin is mainly excreted, though other parts are utilised.

CARBOHYDRATES. A very well-known phenomenon of the excretion of carbohydrates is presented by the so-called "honey-dew" of APHIDAE, COCCIDAE and PSYLLIDAE. According to Davidson (1923) the composition of this liquid excreta of Aphids depends upon the species of plant and the insect concerned, and is closely related to the composition of the cell sap of the plant. This seems to be a largely theoretical consideration. It may be perfectly true, but no actual comparative analytical data are available. Such data would be of great interest for a better understanding of the nutritional requirements of the insects in question. Indeed, even simple analyses of the honey-dew itself are scarce and incomplete, and recent authors base their views on this substance mainly on the old analysis of Boussingault (1872), who found in the Aphid excreta cane sugar, inverted sugar and dextrin. The presence of

the two sugars is not difficult to explain, but the origin of dextrin is not clear (Büsgen, 1891, 1891*a*). Arnhart has recently (1927) studied the "manna," * *i.e.* crystallised excreta, of *Lachnus muravensis* on larches and found it to consist of inverted sugar, 13·94%; cane sugar and melezitose, 53·36%; proteins, 2·78%; and dextrin, 30·30% of the dry substance. Melezitose occurs also in the honey-dew of other Aphids and Coccids feeding on firs (Hudson and Sherwood, 1920).

A special gum-like carbohydrate, animal dextran has been discovered by Liebermann (1887; see also Horvath, 1887) in the excreta of *Schizoneura lanuginosa* living in galls on Ulmus.

A weevil, *Larinus nidificans*, occurring in Syria on Echinops makes a cocoon from a sugary mass (probably excreta) called trehala manna containing 66% starch, a little gum, some salts and 28% of a special sugar described by Berthelot (1858) under the name trehalose (Capiomont et Leprieur, 1874; Guibourt, 1858; Hanbury, 1859; Pierce, 1915).

Some oak-feeding insects have been found by Hollande to develop crystals of tannoid substances in the special calyciform cells of the epithelium of the mid-intestine. This is a case of intracellular excretion of tannin. The same substance has been discovered in the elytra of MELOLONTHIDAE and *Calandra granaria*, also probably as an excretion (Slater, 1887).

IV. ENZYMES.

The available data on the enzymes of insects are more numerous than might be expected. At the same time they are very far from approaching either completeness, even in the case of an insect such as the honey-bee, or the necessary degree of exactitude. There are a few general points worth considering which should be mentioned before the literature on the various enzymes is reviewed.

The usual method of studying the digestive enzymes of insects consists in extracting either the digestive juice, or sections of the digestive tract, and testing the action of the extract on various substances. It is only quite recently that Phillips (1927) and Bertholf (1927) applied another, much more exact, method to the study of the digestive enzymes of the honey-bee, by feeding adult bees on definite chemically pure carbohydrates and comparing the length of their life with the controls fed on water only. In this way, the active enzymes of the digestive juice can be discovered. The other enzymes present (*e.g.* in the tissues of the intestinal tract), which do not take part in the digestion, fortunately do not influence the results obtained by this method. They do, however, invariably do so when extracts of organs are made and tested. This exact method cannot readily be extended to all insects, but where it is possible it may be adopted with great advantage. In any case, special care should always be taken to reduce the chances of error by extracting only the tissues of the organs actually taking part in digestion. Failure to do this has often led to somewhat surprising results. Thus a haemolysin was discovered in Aphids by extracting whole insects; it is doubtful whether this can be a digestive enzyme in the case of insects feeding exclusively on plants. It may be either a metabolic enzyme or not a haemolysin at all, but another enzyme exhibiting similar action on the usual substances which are applied as a test for haemolysin. Similarly, lactase and chymosin were found in the digestive tract of bees, although there are neither lactose nor milk proteins in the normal diet of bees

* Chemical data on the true Sinai manna, which is probably an excretion of COCCIDAE, are very unreliable and here omitted.

(Brown, 1928). These examples show that the somewhat routine methods adopted by many investigators of insect enzymes are more likely to multiply the data on enzymes found in various insects than to elucidate their rôle in the digestion of normal foods, which should be the main aim of the work.

Further, Phillips (1927) pointed out that a considerable number of enzymes found in the digestive tract of insects may be produced not by insects themselves, but by symbiotic or parasitic micro-organisms living in the tract, and quite recently Brown (1928) actually discovered that sterilised bees contain only three enzymes in their digestive tract, as against nine previously found in bees by workers who did not pay attention to the enzymes produced by micro-organisms. In some cases, it is true, such enzymes, although not produced by the insects themselves, do nevertheless play a most important part in their digestion. For instance, the digestion of cellulose by termites is impossible without the aid of symbiotic Protozoa. Numerous examples of this kind are quoted elsewhere in the present paper (see pp. 266, 268), and further research is very likely only to multiply their number. The necessity of distinguishing between the enzymes produced by the insect and by its symbionts or parasites should be clear and need not be discussed.

From the following list of insects in which various enzymes have been found, it would appear that there is little difference in the enzyme complexes between insects of widely varying feeding habits, since, *e.g.*, both proteases and diastases occur almost equally commonly in carnivorous insects and in purely phytophagous ones. The difference, however, may be due to the somewhat generalised nature of the classification of enzymes as proteases, lipases, etc. Actually, they may be very specialised in each case. On the other hand, there is always a quantitative difference, as has been shown by Bounourc (1911), who determined the relative quantities of the four main enzymes in several species of insects with different diets, as follows :—

	Protease.	Lipase.	Diastase.	Invertase.
Dytiscus marginalis (carnivorous) . .	12	5·6	10	0·66
Hydrophilus piceus (mainly phytophagous) .	6·1	10·7	56·07	62·55
Geotrupes sylvaticus (coprophagous) . .	4·8	6·0	43·60	34·30
Melolontha melolontha (phytophagous) .	1·0	37·2	38·7	12·4
Polyphylla fullo (phytophagous) . .	0·0	33·5	49·1	11·5

It will be seen from the above table that the proteolytic enzyme is very abundant in the wholly carnivorous *Dytiscus*, and almost or entirely absent in the phytophagous *Melolontha* and *Polyphylla*; similarly, though diastase and invertase are present in *Dytiscus*, they are much more evident in the two phytophagous species, and lipase is also more abundant in the latter. All this suggests that there is a close connection between the normal alimentary regime and the presence, or absence, of certain enzymes. There is, of course, nothing surprising in this conclusion, but some instances have already been quoted in which enzymes of a kind never likely to be of service in the digestion of normal food have been recorded from insects. Cases of this sort deserve a close study, not a mere record.

The variation in the enzymes of a single insect during its development present an interesting problem, which has not yet been studied. Straus (1909) is the only author who has made observations on enzymes of Lepidoptera in different stages. He found that the inulinase, which is present in larvae, is absent

from pupae, and that the quantity of diastase and of maltase in the latter decreased, as compared with larvae. Glycogenase was absent from pupae, but appeared in the adults. Roques (1909) studied the variation in the quantity of enzymes during the development of *Limnophilus flavicornis*, with the following results :—

	Diastase.	Invertase.	Protease.
Young larvae	0·5	0·0	4·0
Older larvae	1·1	0·7	8·0
Young nymphs	0·4	1·5	2·0
Older nymphs	0·6	2·3	4·5
Adults	1·6	2·3	10·0

Sarin (1923*a*) studied the quantity of invertase in the stomach of honey-bees throughout the year. Scarcely any invertase was found in late autumn and early spring, when they feed on honey containing only inverted sugar, and a little saccharose. This means that the enzyme is prepared only when it is wanted, and failure to find a certain enzyme in an insect cannot be taken as definite proof that the insect is unable to produce it.

The summary of the data on enzymes recorded from insects is the result of a very thorough search through the literature, and it is hoped that only a few scattered records have escaped notice. It must be specially mentioned, however, that attention has been principally concentrated on the collection of records of digestive enzymes. Oxidising and allied enzymes have in the main been omitted, and papers dealing only with them have been excluded from the bibliography. With this exception, the bibliography is, at any rate, much more complete than the latest list of insect enzymes in Oppenheimer's monograph on enzymes (1925–1926), since, for instance, there are in the present list nearly thirty references to lipase, as against eight in that monograph.

When compiling the list it seemed natural and useful to include references not only to papers where a certain enzyme is mentioned by name, but also to those containing definite indications that an insect is able to digest certain substances. For instance, an indication that starch is digested is listed as a reference to the presence of diastase, even though the enzyme is not mentioned.

The classification and nomenclature of enzymes is that adopted in the recent book by Waksman and Davison (1926). In a few cases of doubtful and little-known enzymes the original name is given. The references under each heading are arranged alphabetically by authors.

(*a*) Enzymes acting upon Fats.

Lipase. Abbott, 1926 (*Periplaneta australasiae*); Acqua, 1916 (silkworm; the same author in 1920 recorded the absence of lipase from the same insect); Biedermann, 1898 (*Tenebrio molitor*); Biedermann, 1919 (*Gastropacha rubi*, Acrididae); Bounoure, 1911 (*Dytiscus marginalis, Hydrophilus piceus, Geotrupes sylvaticus, Melolontha melolontha, Polyphylla fullo*; quantitative determinations, see above, p. 296); Brown, 1928 (sterilised honey-bees, found once only); Dirks, 1922 (various caterpillars and cockroaches); Gorka, 1914 (*Gnaptor*, in the Malpighian tubes); Kawase, Suda and Saito, 1921 (silkworm); Kemnitz, 1917 (larva of *Gastrophilus equi*); Pavlovsky and Zarin, 1922 (honey-bee); Plateau, 1876 (*Periplaneta americana*); Porta, 1903 (insects); Sandias, 1908 (*Periplaneta orientalis* and *P. americana*); Sanford, 1916, 1918 (cockroach);

Sarin, 1923 (honey-bee); Sawamura, 1902 (silkworm); Straus, 1909 (larva of *Bombyx mori* and some other Lepidoptera); Swingle, 1926 (*Blatta orientalis*); Wigglesworth, 1928 (cockroaches; a lipase usually but not constantly activated by sodium glycocholate).

It will be seen that lipase is widely distributed in insects, without any apparent regard to their feeding habits, but it is highly probable that some of the records refer to lipolytic enzymes charged with a metabolic (intracellular) function and not with a digestive function. Further, it is clear that many different lypolytic enzymes are grouped under one heading.

Chlorophyllase? Biedermann (1919) observed that in *Forficula auricularia* the digestion of chlorophyll results in the formation of (probably) phaeophorbine, which suggests the presence of an enzyme similar to chlorophyllase.

Enzyme acting on Wax. A special lypolytic enzyme acting on wax has been found by Sieber and Metalnikow (1904), and also by Fliessinger (1910) in larvae of *Galleria melonella* feeding on wax (see p. 271). Šulc (1911) found an analogous enzyme in the anal fluid of *Philaenus lineatus*, where the enzyme serves to split up the waxy secretion. In this case the enzyme has obviously no digestive function.

(*b*) Enzymes acting upon Carbohydrates.

Cellulase. Belehradek, 1922 (saliva of *Dixippus morosus*); Biedermann, 1919 (phytophagous Orthoptera); Hering, 1926*b* (larva of *Cemiostoma*); Springer, 1915 (larvae of *Miastor* feeding on decaying bark of trees; compare above, p. 269, and Harris, 1923); Smith, 1926 (Coccidae, cell walls dissolved by saliva).

Cytase (hemicellulase). Biedermann, 1919 (phytophagous Orthoptera).

Xylanase. Seillière, 1905 (larvae of *Phymatodes variabilis*).

Inulase. Kobert, 1903 (*Melolontha melolontha*); Pavlovsky and Zarin, 1922 (honey-bee; the record is not quite clear, there being some discrepancy between the text and the table of enzymes found; see Phillips, 1927; this latter author failed to find inulase in honey-bee); Straus, 1909 (larvae of *Bombyx mori* and of *Hyponomeuta* sp., not found in their pupae or adults).

Diastase (amylase). Abbott, 1926 (*Periplaneta australasiae*); Acqua, 1916 (silkworm); Basch, 1859 (*Blatta orientalis*); Belehradek, 1922 (*Dixippus morosus*); Biedermann, 1898 (*Tenebrio molitor*); Biedermann, 1911 (Lepidopterous larvae; an amylolytic enzyme entirely different from that in other insects); Bounoure, 1911 (*Dytiscus marginalis, Hydrophilus piceus, Geotrupes sylvaticus, Melolontha melolontha, Polyphylla fullo*); Brown, 1928 (honey-bee, but not found in sterilised bees; Phillips, 1927, failed to prove the presence of diastase in bees); Büsgen, 1891 (Aphidae); Dirks, 1922 (various caterpillars and cockroaches; apart from the diastase, an enzyme acting on soluble starch was also determined); Frenzel, 1882 (larva of *Tenebrio molitor*); Gorka, 1914 (Malpighian tubes of *Gnaptor*); Grüner, 1900 (*Aphrophora* and *Philaenus*; a ptyalin-like enzyme in the saliva); Jameson and Atkins, 1921 (silkworm); Jousset, 1876 (*Blatta orientalis*); Kawase, Suda and Saito, 1921 (silkworm; the enzyme is identified by the authors as amylopsin, which produces from starch maltose and achroodextrin); Kemnitz, 1917 (larvae of *Gastrophilus equi*); Kobert, 1903 (*Melolontha melolontha, Musca domestica*, pupae of *Lasiocampa pini*, dried ants' pupae); Nenjukov, 1927 (adult *Pieris brassicae* and *Vanessa urticae*); Pavlovsky and Zarin, 1922 (honey-bee; see above under Brown); Plateau, 1873 (*Hydrophilus*, Scarabaeidae, *Stethophyma*, caterpillar of *Liparis*

monacha); Plateau, 1876 (*Periplaneta americana*): Roques, 1909 (*Limnophilus flavicornis*; variation in the action of the enzyme in all stages of development, see above, p. 297); Sandias, 1908 (cockroaches); Sarin, 1923 (honey-bee); Sawamura, 1902 (silkworm); Sieber und Metalnikow, 1904 (larva of *Galleria melonella*); Staniland, 1925 (*Eriosoma lanigerum*); Straus, 1909 (caterpillars); Swingle, 1926 (*Blatta orientalis*); Wigglesworth, 1927*a* (cockroaches); Wollmann, 1922 (sterile larvae of *Calliphora* and *Lucilia*); Zweigelt, 1915 (saliva of Aphids).

It will be seen from this long list of references that enzymes acting on starch are very common in insects, but there is no reason to think that they are all identical. There are, indeed, some indications that are in favour of the specificity of these enzymes in different insects, perhaps depending on differences in food. In some cases diastase may be produced not by the insect but by symbiotic micro-organisms, in which case the results may even be disastrous for the insect. Thus, in the case of honey-bees (Brown, 1928), dextrins resulting from the activity of diastase are a cause of dysentery.

Glycogenase. Dirks, 1922 (various caterpillars); Kobert, 1903 (*Musca domestica, Melolontha melolontha*, pupae of *Lasiocampa pini*); Straus, 1909 (in larvae and adults of *Bombyx mori*, but not in pupae).

The data on glycogenase are too fragmentary to permit any conclusions to be drawn, but it would seem that the enzyme is almost purely metabolic and has no digestive function.

Dextrinase. Bertholf, 1927 (larvae of the honey-bee).

Raffinase. Straus, 1909 (caterpillars).

Melezitase. Bertholf, 1927 (larvae of the honey-bee).

Invertase (invertin, sucrase). Abbott, 1926 (*Periplaneta australasiae*); Axenfeld, 1903 (honey-bee, wasps, Diptera, butterflies, beetles, larva of *Carpocapsa pomonella, Cicada*, but not in the silkworm); Bertholf, 1927 (honey-bee larva); Biedermann, 1898 (larva of *Tenebrio molitor*); Bounoure, 1911 (*Dytiscus marginalis, Hydrophilus piceus, Geotrupes sylvaticus, Melolontha melolontha, Polyphylla fullo*; quantitative determination); Brown, 1928 (sterilised honey-bees); Dirks, 1922 (various caterpillars and cockroaches); Erlenmeyer, 1874 (honey-bee); Gorka, 1914 (Malpighian tubes of *Gnaptor*); Jameson and Atkins, 1921 (blood of silkworms); Kawase, Suda and Saito, 1921 (silkworm); Nenjukov, 1927 (*Pieris brassicae* and *Vanessa urticae*); Pavlovsky and Zarin, 1922 (honey-bee); Phillips, 1927 (honey-bee); Pieron, 1907 (*Lasius niger*); Roques, 1909 (*Limnophilus galvicornis*; variation of the activity of enzymes during development); Sarin, 1923, 1923*a* (honey-bee; in the second paper seasonal variation of the quantity of the enzyme is studied); Straus, 1909 (caterpillars); Swingle, 1926 (*Blatta orientalis*); Tschirsch and Lüdy, 1923 (*Tachardia lacca*).

Since cane sugar is extremely widely distributed in plants, it is not surprising that invertase is quite common in phytophagous insects, especially in those feeding on nectar, like honey-bees and butterflies. It has, however, also been found in purely carnivorous insects, *e.g.*, *Dytiscus marginalis*.

Maltase. Abbott, 1926 (*Periplaneta australasiae*); Bertholf, 1927 (honey-bee larvae); Dirks, 1922 (various caterpillars); Jameson and Atkins, 1921 (silkworm); Phillips, 1927 (honey-bee); Sawamura, 1902 (silkworm and *Caligula japonica*); Straus, 1909 (caterpillars); Wigglesworth, 1927*a* (cockroach).

Trehalase. Bertholf (1927) and Phillips (1927) discovered that honey-bee larvae and the adult bees are able to live on pure trehalose, which means that they possess an enzyme for splitting up this carbohydrate, although it is known never to occur in their normal food.

Lactase. Bertholf, 1927 (honey-bee larvae); Pavlovsky and Zarin, 1922 (honey-bee; Brown, 1928, did not find lactase in sterilised bees and expressed doubts whether it may be necessary for the bee, since lactose does not occur in the normal food); Straus, 1909 (caterpillars); Wigglesworth, 1927*a* (cockroach).

Glucosidases (including emulsins). Glucosidases, without more special designation, were found by Biedermann, 1898 (larva of *Tenebrio molitor*); Dirks, 1922 (various caterpillars and cockroaches); and Gorka, 1914 (Malpighian tubes of *Gnaptor*). Brunswick, 1923, recorded emulsin in *Melolontha melolontha*. Kobert (1903) studied enzymes acting on various glucosides in a series of insects, and found the following enzymes: amygdalase (*Melolontha melolontha*, pupae of *Lasiocampsa pini*, ants' pupae), salicase (*Melolontha*, ants' pupae; Axenfeld, 1903, recorded this enzyme from silkworm), helicase (pupae of *Melolontha*, ants' pupae), arbutase (*Melolontha*, ants' pupae), phloridzinase (*Musca domestica*, *Melolontha*, ants' pupae), coniferase (pupae of *Lasiocampa pini*, *Melolontha*, ants' pupae), aesculase (pupae of *Lasiocampa pini*, *Melolontha*, ants' pupae), quercitrase (*Melolontha*, dry *Coccinella*). Aesculase has been found also by Axenfeld, 1903, in silkworm.

Formizyme. Under this name Kobert (1903) mentions a ferment contained in ants' pupae which produced formic acid from glycogen, glucose, amylodextrin, grape sugar, maltose and cane sugar.

An Enzyme acting upon Chitin. Kemner, 1926; Schulze, 1927 (beetle, *Platydema tricuspis*, feeding on a fungus); Ramme, 1920 (larva of *Pseudagenia* feeding on spiders).

(*c*) Enzymes acting upon Proteins and their Derivatives.

Coagulating Enzymes. Weinberg (1908) stated that the larvae of *Oestrus* secrete a substance which coagulates blood and dissolves red corpuscles. Cornwall and Patton (1914) found that the saliva of many blood-sucking insects contains anti-coagulin, but that in some of the species examined it was absent. There is a fair number of records that blood-sucking insects emit a salivary secretion preventing coagulation of blood, but the enzymes have never been studied.

Rennet (lab, chymosin). Pavlovsky and Zarin (1922) also Sarin (1923) recorded chymosin in the honey-bee; Brown (1928) did not find it in sterilised bees and doubts its digestive function. Sieber and Metalnikov (1904) found chymosin in the larva of *Galleria melonella*. Apparently, the same ferment is recorded by Kobert (1903) under the name of caseinogen in old dry museum specimens of *Coccinella* and Cantharidae. He failed, however, to find it in fresh specimens of *Melolontha melolontha*.

Proteases (not specified). Abderhalden und Heise, 1909 (*Libellula*, *Blatta orientalis*, larva of *Tenebrio molitor*, larva of *Blaps*, *Pieris brassicae*, *Porthesia chrysorrhoea*); Acqua, 1916 (silkworm); Biedermann, 1898 (larva of *Tenebrio molitor*); Biedermann, 1919 (phytophagous insects); Bounoure, 1911 (*Dytiscus marginalis*, *Hydrophilus piceus*, *Geotrupes sylvaticus*, *Melolontha melolontha*, *Polyphylla fullo*); Dirks, 1922 (various caterpillars and cockroaches); Fabre (larvae of the Blue-bottle); Inouye, 1912 (silkworm, a metabolic proteolytic enzyme, the nature of which has never been studied); Jordan, 1910 (*Carabus auratus*); Kemnitz, 1917 (larvae of *Gastrophilus equi*); Nazari, 1899 (silkworm); Lengerkern, 1921 (larva of *Carabus auratus*); Petersen, 1912 (honey-bee); Plateau, 1873 (*Dytiscus*, *Carabus*); Plateau, 1876 (*Periplaneta americana*); Porta, 1903 (general considerations on proteolytic enzymes in insects);

Roques, 1909 (*Limnophilus flavicornis*, variations in the activity of the enzyme during the different stages of the development); Sandias, 1908 (*Periplaneta americana*, *Blatta orientalis*); Sarin, 1923 (honey-bee); Sieber und Metalnikov, 1904 (larva of *Galleria melonella*); Vogel, 1915 (larva of *Lampyris noctiluca*); Wollman, 1921, 1922 (larvae of *Calliphora* and *Lucilia*).

Trypsin. Abbott, 1926 (*Periplaneta australasiae*); Blunck, 1923 (*Dytiscus marginalis*); Brown, 1928 (sterilised honey-bees); Frenzel, 1882 (larva of *Tenebrio molitor*); Kawase, Suda and Saito, 1921 (silkworm); Kobert, 1903 (*Melolontha melolontha*, *Musca domestica*, cochineal, *Lytta vesicatoria*); Korschelt, 1924 (*Dytiscus marginalis*); Nagel, 1896 (*Dytiscus marginalis*); Pavlovsky and Zarin, 1922 (honey-bee); Portier, 1909 (*Dytiscus*); Sawamura, 1902 (silkworm); Stuhlmann, 1907 (*Glossina fusca* and *G. tachinoides*); Swingle, 1926 (*Blatta orientalis*); Weinland, 1906*a*, 1907 (larvae of *Calliphora*); Wigglesworth, 1928 (cockroach, a tryptase resembling pancreatic trypsin in its properties).

Pepsin. Pavlovsky and Zarin (1922), also Sarin (1923), recorded pepsin from the honey-bee, and Brown (1928) found it in sterilised bees.

Erepsin. Swingle, 1926 (*Blatta orientalis*); Wollmann, 1922 (larvae of *Calliphora* and *Lucilia*).

Fibrin Protease. Basch, 1859 (*Blatta orientalis*); Straus, 1909 (various caterpillars).

Fibroin Protease. Abderhalden, 1922 (*Anthrenus museorum*).

Asparaginase. Takeushi and Inouye, 1909 (silkworm and its moth; the rôle played by asparaginase in metabolism is unknown).

An Enzyme acting on Keratin. Sitowski (1905) suggested that the larva of *Tineola biselliella* (clothes moth) feeding on hair must possess a special enzyme for the digestion of keratin, but later (1910) he concluded that the main food of the larvae is not keratin, but other substances present in the hair. Titschak (1922) and Babcock (1912) maintain that the larvae can digest keratin, but the enzyme has never been isolated.

Haemolysins. Bruck, 1911 (saliva of *Culex pipiens*); Dewitz, 1915 (extract of Aphids found to have a definite haemolytic action on mammalian blood; the name aphidolysin is offered for the active substance; see also Börner, 1915); Galli Valerio, 1916 (saliva of *Culex pipiens*); Klausner, 1916 (poison of bed-bugs). Weinberg (1908) records that a secretion of the larvae of *Oestrus* is able to dissolve the red corpuscles of horse blood.

(*d*) Other (mainly metabolic) Enzymes.

Since the majority of the enzymes referred to under the foregoing heading are either metabolic (without any more precise definition of their function), or definitely connected with gaseous exchange, no attempt has been made fully to review the literature on them.

Oxydases. Biedermann, 1898 (digestive juice of the larva of *Tenebrio molitor*); Kawase, Suda and Saito, 1921 (blood of silkworm); Kemnitz, 1917 (blood of larvae of *Gastrophilus equi*; both oxydase and peroxydase found); Straus, 1909 (oxydase regularly found in caterpillars); Gorka, 1914 (peroxydase in the Malpighian tubes of *Gnaptor*).

Tyrosinase. Biedermann, 1898 (digestive juice of the larva of *Tenebrio molitor*); Fürth u. Schneider, 1902 (an enzyme corresponding to tyrosinase was found to be regularly present in the haemolymph of various insects, causing the blackening of the haemolymph on its contact with the air); Gorka, 1914 (in the Malpighian tubes of *Gnaptor*); Kawase, Suda and Saito, 1921 (blood of

silkworm); Portier, 1909 (digestive juice of *Dytiscus*); Vaney et Pelosse, 1922 (tyrosinase in haemolymph of silkworm is secreted by leucocytes, and plays a part in the oxydation of pigments derived from the food).

Catalase. Zieger (1915) made determinations of the catalase content of many insect species, and an analysis of the figures shows that there is no relation between the catalase content and food habits. The catalase content, however, changes greatly during development, there being apparently some connection between the catalase and the development of genital products at the cost of the fat body. Spooner (1927) studied the catalase content of Codling moth larvae and found that it is directly correlated with the health of larvae and probably also with pupation, since it increases towards the time of pupation. Pavlovsky and Zarin (1922) and also Sarin (1923) found catalase in extracts of the digestive organs of the honey-bee, but Brown (1928) believes that catalase is scarcely likely to take any part in the digestion; moreover, no catalase was found by him in sterilised bees, though great quantities of catalase are produced by aërobic bacteria, which are abundant in the digestive tract. (See also Jameson and Atkins, 1921; Kobert, 1903; Gorka, 1914.)

Aldehydase. Gorka, 1914 (extract of Malpighian tubes of *Gnaptor*).

Zymase. Kobert, 1903 (ants' pupae).

V. METABOLISM.

(*a*) Nitrogenous Substances.

Nitrogen Metabolism. The general processes of nitrogen metabolism have been studied in detail in the Tent caterpillar (*Malacosoma americana*, F.) by Rudolfs (1926*a*, 1927), and Russo (1922) and Inouye (1912) have published important data on the silkworm. The main results of Rudolf's work are as follows :—

The average nitrogen content of the total egg-masses from the time that they are deposited to the hatching of larvae is about 13%, but is subject to some fluctuations. Just before hatching an increase in nitrogen content occurs, and it reaches 15·1%. As soon as the newly-hatched larvae begin to feed, the total nitrogen drops considerably, to 12·5%, and finally even to 10·5%. These figures show that the body-weight of growing caterpillars increases at a greater rate than its nitrogen content; large quantities of fats being stored during this period. Nitrogen decreases considerably from the time the larvae are full grown, but increases again during the pupal stage. Adults contained less nitrogen than the pupa in the last stage. On the whole, nitrogenous substances are of special importance at three critical stages in the development: (*a*) when the larvae are formed, (*b*) when they are preparing to pupate, and (*c*) when the pupae are changing to the adult stage.

Russo (1922) has also found that the newly-emerged silkworms contain more nitrogen than the eggs, which implies a consumption of non-nitrogenous substances during the embryonal development; the quantity of non-protein nitrogen also increases in the larvae owing to the hydrolysis of proteins. During the larval development, the quantity of protein nitrogen decreases during the first ten days (because of the accumulation of carbohydrates and fat, which goes on more rapidly than that of proteins); during the second period of ten days, equilibrium is attained, and during the third such period proteins are built up.

Heller (1925, 1926) made interesting comparisons between caterpillars

of two different species, viz. the silkworm which makes a cocoon of silk consisting of amino-acids (see p. 282), and the larva of *Deilephila euphorbiae*, which pupates without a cocoon. The following data embody the main result :—

	Bombyx mori.	*D. euphorbiae.*
Lost during pupation :	%	%
In nitrogenous substances	63	19
In fats	14	42
Lost during the pupal stage :		
In nitrogenous substances	9	32
In fats	23	5
Content of adults at the emergence :		
In nitrogenous substances	29	50
In fats	63	52
Content after fifteen days of adult life :		
In nitrogenous substances	—	31
In fats	—	14

These figures show that in the silkworm the metamorphosis into the pupal stage is made at the cost of carbohydrates, and that proteins (or amino-acids) are used for building the cocoon. Pupal metabolism in the silkworm concerns mainly fats; but *Deilephila* consumes mainly nitrogenous substances. As an adult insect *Bombyx mori* still contains 63% of fats and only 29% of proteins; it dies very soon after emergence (being unable to feed). Adult specimens of *Deilephila* live for fifteen days, and even at the end of that period still contain as much nitrogen as a freshly emerged *Bombyx*. During that time the *Deilephila* consumes fats.

Further data on nitrogen metabolism may be found in E. Abderhalden's paper, 1923; Farkas, 1903; Slowtzoff (all papers); Straus, 1911; Tangl, 1909; Vaney et Maignon, 1905; Weinland, 1906*a*, 1909, 1910; Kawase, Iwaoka and Saito, 1913.

Synthesis of Proteins. Loeb (1915) made a series of experiments intended to discover the source of nitrogenous compounds required for the development of the fly *Drosophila melanogaster*. The culture consisted of a solution of pure sugar, certain inorganic salts and a small quantity of one, or two, amino-acids, or certain ammonium salts. Larvae on this food grew to full size and produced normal flies. It would appear that in these experiments the larvae were actually able to manufacture all the complicated nitrogenous compounds of their body from amino-acids, or from ammonium salts; this would indicate a power of synthesis equal to that of bacteria. However, though everything used in the experiments was sterilised, the flies themselves were not sterile and it is possible that bacteria were present. Baumberger (1917), when breeding *Drosophila* under absolutely sterile conditions, found that the insect depends for its protein on micro-organisms and has no greater synthetic power than the higher animals.

Bogdanow (1928) raised eleven successive generations of the fly *Calliphora erythrocephala* exclusively on human excreta, *i.e.* on a food extremely poor in proteins, and deduced from this that the insect can build up proteins from the simplest nitrogenous compounds. Bacteria, however, were not excluded from the experiment, and its results therefore cannot be considered convincing.

More suggestive are E. Abderhalden's studies (1925) on the beetle *Anthrenus museorum*, the larvae of which can develop on pure silk not containing any fats or carbohydrates, though in these experiments the sterility of food and of the insects was not observed.

Synthesis of tryptophane takes place in the pupae of *Musca vomitoria* according to Jezewska (1926); this was confirmed by Zabinski (1928), but micro-organisms were not excluded.

In general, therefore, it may be said that the ability of insects to build up proteins from simpler nitrogenous compounds in their food has not been proved, since in some apparent cases of synthesis the latter may have been due to bacteria. (On the rôle of micro-organisms in insect nutrition see pp. 266, 268.)

Nitrogenous Reserves. Biedermann (1898) was one of the first to discover protein crystals and crystalloids in the intestinal epithelium of *Tenebrio molitor*. He regarded them as reserves. Kollmann (1909) supported this idea with regard to albuminoid inclusions in the cells of the fat-body of the same insect, basing his view on the fact that the inclusions disappear after a period of starvation. Semichon (1913, 1927) and, especially, Schmieder (1928) studied nitrogenous inclusions of fat-body cells in considerable detail, and the last-named author was inclined to think that there may be some connection between fat and the albuminoids, *i.e.* that intracellular synthesis of proteins takes place. Vogel (1915) mentioned reserve proteins in the fat-body of *Lampyris noctiluca*, and similar fragmentary data may be found scattered in other general histological papers. The metabolism of protein reserves remains, however, as yet unstudied.

Decomposition of Proteins. The products of the decomposition of proteins have been reviewed in part above (pp. 282–3). They are eliminated as excreta (urates, purine bases, etc.), as material for cocoons (amino-acids of silk) and as pigments (see p. 287). The chitinous integuments of insects are also to a certain extent formed at the expense of protein nitrogen (Weinland, 1909) and it is not impossible to regard the formation of chitin as a special case of the elimination of products of decomposition of nitrogenous substances.

The elimination of these products is an extremely important function, since their excessive accumulation in the organism leads to temporary poisoning, which produces interruptions (diapauses) in the development (Roubaud, 1922*a*, 1923), or even death (Metchnikoff, 1915).

Certain products of the decomposition of proteins, namely, extractive substances, were studied by D. Ackerman (1920, 1921, 1922) and by Kutcher u. Ackermann (1926). These authors classify them into four groups: derivatives of purine; derivatives of imidazole; derivatives of guanidine; and leucine. The rôle played in metabolism by these substances with a relatively small molecule is absolutely obscure, as it is in the case of plant alkaloids, with which they can be compared. They may be the products of the splitting up of proteins, or they may themselves be substances of high biological significance.

Poison proteins (Lewin, 1894, 1912; Strohl, 1925) are equally mysterious as regards their metabolic rôle.

(*b*) Fat.

Fat Metabolism. The best and most recent study on fat metabolism is that by Rudolfs (1926; partly also 1927), who studied the fat metabolism in the American Tent caterpillar (*Malacosoma americana*, F.). Fat in the eggs was found to decrease fairly rapidly after deposition and the hatching of the larvae. When the larvae began to feed, an increase in fat was observed. This was at first gradual (during the first two stages), but during the next three stages it became more rapid. In the pupal stage there was a very rapid increase in fat content during the first half of the period, while during the second half the fat content decreased. The lowest fat content was upon hatching, viz. 0·66% of

the dry weight; the highest fat content was when the larvae just pupated, 28·8%. On the whole it appears that fatty substances are used and stored for energy and do not take a very active part at any critical stage of the metamorphosis for the tissue building, which is done mainly at the cost of nitrogenous substances.

Of other Lepidoptera, the silkworm has been studied with regard to its fat metabolism by several authors (Kellner, 1884; Inouye, 1912; Kaneko, 1924; Farkas, 1903). Kellner has found that silkworms just after hatching are very rich in fat, containing about 4% of it, but that the fat content becomes lower for a considerable time and only increases again towards the end of the larval period. In the fifth stage the amount of fat was twice the quantity of fat obtained from food; this means that half the fat was formed in the organism from other substances; Kellner believed that this fat was formed mainly from proteins of the food, but Weinland (1910) in discussing Kellner's data finds it impossible to indicate definitely the source of the excess of fat.

Heller (1925, 1926) made a comparative study of fat metabolism in *Bombyx mori* and *Deilephila euphorbiae*, and found that during pupation *Deilephila* uses up mainly fats (29·40% of the fat content of the pupa), while in *Bombyx* the pupation is made mainly at the cost of non-fats, only 13·80% of fat being used. During the pupal period itself *Deilephila* uses very little fat; indeed, only about one-fifth of the metabolism in the pupa of this species is covered by the splitting of fats, though in *Bombyx* nearly one-half is so covered. This interesting study shows that any generalisations with regard to the main metabolic processes are very dangerous, even when dealing with fairly closely allied insects.

Amongst other insects, fat metabolism was very thoroughly studied in the fly *Calliphora* by Weinland (1906–1910). Fat content in the eggs decreases gradually, fat being used in the development of the embryo. The larva is able to build fat from proteins in the food (see below), and accumulation of fat in the fat-body goes on very rapidly until the fat content reaches its maximum (about 7·8%) just before pupation. During metamorphosis in the pupa, the fat is freely spent and its content is reduced to about one-half of the original quantity. No fat is built in the pupal stage.

Further data on fat metabolism may be found in papers by Dubois et Couvreur, 1901; Farkas, 1903; Pilewiczowna, 1926; Tangl, 1909; Slowtzoff, 1904–1909; Strauss, 1911; Kemnitz, 1917; Kawase, Iwaoka and Saito, 1913; Yamakawa, 1919.

Formation of Fat. Hoffmann (1872) was the first to prove that insects are able to build fats from proteins by feeding larvae of the fly *Musca vomitoria* on defibrinated blood and determining the fat content of the food, the eggs of the flies and their larvae; in one of his experiments, for instance, the fat contained in eggs and in the food consumed by larvae was 0·0196 gr. but the larvae contained 0·2012 gr. of fat. The experiments have been repeated by several authors (Frank, 1897; Nishikata, 1922; Weinland, 1908) with positive results, though Bogdanow (1908*a*) stated that flesh-fly larvae bred on sterile meat contained much less fat than the food. E. Abderhalden (1925) bred beetles of the species *Anthrenus museorum* on defatted silk. They developed normally, forming normal fat reserves, apparently, from the amino-acids of the silk.

There are numerous data on the formation of fat from carbohydrates. Dumas et Milne Edwards (1844) recorded some experiments which showed that bees which were fed exclusively on honey, the fat content of which was determined, produced fat in their bodies as well as wax, one bee producing as much

as 0·0106 gr. of fats. Similar experiments were arranged recently by Eckert (1922), who stated that wax formed by bees fed exclusively on pure sugar did not differ in any way from the normal wax. G. Buchner (1918) says that the formation of wax is probably an anoxybiotic process of synthesis from carbohydrates (mainly sugar), or products of their decomposition.

Johansson (1920) studied the gaseous metabolism of *Tenebrio molitor* in connection with food, and came to the conclusion that the respiratory quotient indicates a formation of fats from carbohydrates. Kemnitz (1917), in his studies of fat metabolism in the larvae of *Gastrophilus equi*, obtained results indicating that the fat in larvae cannot be all obtained directly from fat of the food, which does not contain much of it, but is formed at the expense of carbohydrates or proteins. This must be the case also with many other insects obtaining food poor in fats, like wood-boring insects, *Drosophila*, etc. Timon-David (1927, 1927*a*) specially studied the fats of wood-boring insects, and he concluded that the fat in them is synthetised from the pentoses (particularly the xylose) in the food, but he did not attempt to find out what their actual, not apparent, food was (see p. 266).

On the subject of the formation of fat from starch there is an observation by Lacaze-Duthiers et Riche (1854), who analysed galls and larvae producing them, with the result that the galls were found to be rich in starch, but not in fat or sugar, though the larvae contained much fat. This suggests that fat was formed from the starch. More direct evidence is, however, necessary on this problem.

The transformation of glycogen into fat was described by Kemnitz (1914, 1917) in the case of larvae of *Gastrophilus equi*. He made periodical determinations of the fat, chitin and glycogen content of larvae with the following results:—

	1 February.	15 March.	7 June.
	%	%	%
Fat	12·7	23·8	26·0
Chitin	6·8	6·5	9·0
Glycogen	31·1	20·7	16·0

The figures show clearly a gradual reduction in glycogen and a parallel increase in fat.

Reserve Fat. Reserve fat is accumulated in the cells of the fat-body, though some accumulation can also occur in other cells. The fat-body has been very thoroughly studied anatomically and histologically, but very little has been done on the chemical side of fat reserves.

Wax as a special form of fat reserves was studied by Hollande (1914*a*), who found it in special cells called oenocytes or cerodecytes.

Vaney et Maignon (1907) pointed out constant differences in the fat reserves of the two sexes of *Bombyx mori*, the males containing more fat than the females in all stages of their development.

(*c*) Glycogen.

Glycogen Metabolism. Kemnitz (1914, 1917; see above) studied the changes in the glycogen content of the larvae of *Gastrophilus equi*, with the result that a consumption of glycogen was observed, with the parallel formation of fat from it. Straus (1911) in his studies on the metabolism of bee-larvae found that the glycogen in them is of the greatest importance as a reserve material,

its content towards the end of the larval period rising to 33·48% of dry weight. During pupation about 95% of the glycogen is consumed. These figures apply to worker larvae. In the larvae of drones the glycogen content is lower, but still exceptionally high when compared with that of other insects. The great importance of glycogen in the metabolism of bee-larvae may be due to the high carbohydrate content of their food (see also Snodgrass, 1925).

Bataillon (1893; also Bataillon et Couvreur, 1892) studied glycogen metabolism in the silkworm. They found that the high glycogen content of the full-grown larva is not due to a gradual increase of glycogen. On the contrary, the increase begins suddenly and without a direct connection with alimentation. In four days the larva more than doubles its glycogen content. In the pupa glycogen gradually decreases, and in the adult only traces of it are present. (See also Kaneko, 1924.)

Vaney et Maignon (1907) compared the glycogen content of the two sexes of *Bombyx mori*, with the result that females in all stages of development are richer in glycogen than the males.

Sources of Glycogen. Strauss (1911) believed that the high glycogen content of bee-larvae is due to the high carbohydrate content of their food. Kaneko (1924) also believes that the glycogen of the silkworm is built up from carbohydrates of the food in the intestinal epithelium.

Kemnitz (1914, 1917) for the larvae of *Gastrophilus equi* and Külz (1881) for larvae of *Musca vomitoria* stated that glycogen is formed from proteins of the food.

Transformation of Glycogen. Kemnitz (*l.c.*) obtained figures of analyses of *Gastrophilus* larvae, which indicated that glycogen may be a source for the formation of fat (see p. 306).

(*d*) Other Carbohydrates.

Data on carbohydrate metabolism are very scanty.

Bataillon (1893; Bataillon et Couvreur, 1892) studied sugar metabolism in silkworms. Sugar appears when there is an increase in glycogen and the curve of increase is parallel for the two substances, but when the glycogen content falls, the sugar still increases and reaches its maximum a few days before the emergence of the moth.

The formation of chitin must be a very important process of carbohydrate metabolism in insects, but the problem has never been studied. Weinland (1909, 1910) points out that chitin is formed in the pupa at the expense of protein.

Maignon (1903) found that the tissues of silkworms or of newly-formed pupae did not contain any trace of glucose, which appeared only towards the end of the pupal stage. It then increased and was always present in the adults. The production of glucose could be accelerated under anaërobic conditions (see also Yamakawa, 1919).

(*e*) Ash.

The metabolism of ash elements in the insect body remains almost entirely unstudied. It is only quite recently that Rudolfs (1927) published some data of his observations on *Malacosoma americana* concerning the metabolic changes in soluble ash and sulphates. Soluble ash, of course, represents only a portion of the total ash and comprises mainly carbonates and sulphates, these being products of the decomposition of fats, carbohydrates and proteins. The analyses showed that the soluble ash in the eggs of *M. americana* increased

rapidly, from 0·41% to 1·85% in 26 days; later it increased up to 2·90%, and larvae when just hatched contained 5·46% of soluble ash. Five days after hatching the percentage was 3·52%, and the maximum, 7·37%, was reached at the time when the growth of caterpillars was greatest. During the pupal stage a persistent increase took place (due to the decomposition of glycogen). Sulphates increased in eggs during the formation of larvae. Larvae when feeding actively contained less sulphates than the eggs. The sulphate content of the larvae fluctuated and that of the pupae and adults was low.

Sulphur metabolism in the clothes moth larva presents a special interest, since this insect feeds on hair, *i.e.* on keratin containing 2·23–2·58% of sulphur. Investigations by Titschak (1922) have shown, however, that the percentage of sulphur in the excreta is nearly double that in the food (see p. 294), which means that probably all the sulphur eaten is excreted.

Phosphorus metabolism has never been studied in insects, in spite of the obvious importance of that element. Analytical data on mulberry leaves, silkworms and their excreta published many years ago by Péligot (1852, see p. 293) include interesting figures with regard to the phosphorus metabolism. The phosphorus content of silkworm eggs was found to be very high, amounting to 53·8% of the total ash. Mulberry leaves contain 10·3% of phosphoric acid, silkworms 29·0% and their excreta 7·6% of the total ash. This means that the phosphorus of the food is extensively utilised by the insects. The total ash of the silkworms constitutes about 9–11% of body-weight when they are young, but later it is reduced gradually to about 4% at the time of the pupation, when the ash is very rich in magnesium phosphate.

The importance of phosphorus in the development of the embryo in the egg is shown also by Pantel's (1919*b*) observation, that in the hatching larva the Malpighian tubes contain calcium phosphate.

Calcium metabolism is another problem worth special study, since calcium appears to be the most common element in insect excretions (see above, p. 293). Pantel (1919*b*) was inclined to think that calcium, like phosphorus, plays an important part in the embryonal development of PHASMIDAE. The evidence in favour of this view is that there is more calcium phosphate in the Malpighian tubes of hatching larvae than there is inorganic calcium in the egg. This means that there must be some considerable amount of calcium present in organic compounds. Koehler (1920) suggested that calcium may play an important part in the nutritional processes of the honey-bee and other insects (see above, p. 279), while Krüger (1926) thought it might be of importance in gaseous metabolism (Hatano, 1916, and Hatano and Thorii, 1916, published observations on calcium metabolism of the silkworm, but the papers are inaccessible).

Iron metabolism was studied by Harnish (1925) in the larvae of *Chironomus*, and iron appears to take part in gaseous metabolism (see p. 281).

Muttkowski (see above, p. 279) suggested, though mainly on theoretical grounds, that copper is also an element of special function in gaseous exchange.

It is abundantly clear from these scanty data on the metabolism of mineral elements that extensive studies in this direction are urgently required, and that the field for the work is unlimited and practically virgin.

VI. THE INFLUENCE OF DIET ON GROWTH AND REPRODUCTION.

In the present chapter an attempt is made to summarise the available information on the influence of definite components of the diet on the development, growth and reproduction of insects. In accordance with the main aim of the present paper, as defined in the introduction, this should be the most important chapter. One would expect to find in it definite answers to many important problems in the biology of insects and in their interrelations with man. Unfortunately, the data available are exceedingly scanty, since research work on insect dietetics has scarcely been begun. Indeed, most of the data obtained have been disclosed more or less accidentally in the course of other studies. As a result, the present summary is very poor in definite conclusions, the data on most questions being either contradictory or insufficient. Nevertheless it seems useful to give a survey of the known facts, especially as this has not been done before.

(*a*) Nitrogen.

A very large number of insects are able to dispense with nitrogen in their food altogether, but only during some definite stages in their development. Thus, adult butterflies and moths feed exclusively on flower nectar, which contains hardly any nitrogen; moreover, if there were some nitrogen in their food (*e.g.* pollen) they would be unable to utilise it owing to the lack of the necessary digestive enzymes for proteins (Nenjukov, 1927). They not only lead a very active life on a diet of pure carbohydrates, but even develop their genital products on it. This can be rendered possible obviously only at the cost of reserve proteins and fats, accumulated during the larval period, when the larvae feed energetically mainly on the proteins of plants (see p. 262). Flies are also able to live on a diet of pure carbohydrates even longer than on diets devoid of the latter (Vinokurov, 1922), but food containing nitrogen is necessary for the production of eggs in the house-fly (Roubaud, 1922).

These data refer to adult insects which do not require any substances for their growth and further development. The case is, however, different in the case of the growing stages, or even of such adults as apparently do not possess sufficient reserves for the development of genital products. For instance, adult mosquitoes of both sexes can live normally on a pure sugar diet, but the females normally require a meal of blood for the development of eggs, males remaining vegetarian all their life (Genna, 1923; Howard, Dyar and Knab, 1912; Sen, 1918; the last-named authors assert that mosquitoes can lay eggs even after being fed on cane sugar only, but there are no actual observations recorded in support of their view).

Zabinski (1928, 1928*a*) made very important experiments with breeding cockroaches on definite synthetic diets, including two diets without nitrogen, one consisting of 96 parts of saccharose and 4 parts of salts mixture, the other of 66 parts of starch, 30 of saccharose and 4 of salts. On such food cockroaches (larvae) can live a long time, *i.e.* up to six months, but they do not grow and their weight remains the same. On a synthetic food in which the percentage of nitrogen only was reduced as compared with the complete food, the rate of development was very slow.

As regards the influence of different forms of protein, Baumberger (1919) points out that nucleoproteins in the larval food are necessary for the production of eggs in the adult *Drosophila*, which itself does not require any nitrogenous

food, and, indeed, survives on sugar-agar for a much longer period than on yeast-agar (Baumberger, 1917). As a matter of fact, a diet of pure carbohydrates in the adult insect seems to be rather favourable for prolonging the life of the individual insect, but a diet with nitrogen, though it stimulates the production of eggs and ensures the propagation of the species, results in a shorter individual life. Such, at least, is the case of adult mosquitoes (Howard, Dyar and Knab, 1912).

Guyénot (1917), in his excellent studies on the development of *Drosophila ampelophila* upon various synthetic media, arrived at the conclusion that lipoids, and particularly lecithin of the egg-yolk, are the most useful food, the larvae growing rapidly, reaching full size and forming adipose tissue. Some of the larvae even pupated, though not till after 20–25 days, instead of the normal six. Adult flies also may be bred on lecithin more successfully than on any other artificial food, and lay eggs normally. Experiments by the same author with nucleoproteids (yeast protein) have not given definite results, owing to technical difficulties. A food composed of peptone, lecithin and mineral salts forms a complete food, apart from vitamins (see below).

There are some data on the influence of nitrogenous compounds more simple than proteins. Zabinski (1928) bred cockroaches on a diet in which complete protein was replaced by an incomplete one, viz. gelatine, not containing such important amino-acids as tyrosine and tryptophane (20 parts of gelatine, 56 of starch, 20 of saccharose, 4 of salts mixture), and found that they developed at about the same rate as on a complete diet, vitamins in both cases being absent.

A still simpler nutrient medium used by the same author included only the simplest amino-acids, viz. glycocol (15 parts of glycocol, 61 of starch, 20 of saccharose, 4 of salts mixture), and one female of *Blattella germanica* reached even the adult stage, but 45 days later than insects fed under normal conditions. Micro-organisms, however, were not excluded, and it is possible that the insects received their protein, or other nitrogenous compounds, through them.

A diet consisting only of amino-acids of silk was found sufficient for the normal development of larvae and beetles of *Anthrenus museorum*. The same larvae were proved to be unable to survive on gelatine or on a mixture of amino-acids. On casein the larvae survived for a long time, but only a few of them produced adults (E. Abderhalden, 1925).

Loeb (1915, 1915*a*) bred larvae of *Drosophila* on an artificial food consisting of pure sugar with inorganic salts, but without any nitrogenous substances. The larvae hatched and increased slightly in size during the first days, but then their growth stopped, although they survived without any nitrogen for some time. When, however, a small quantity of one or two amino-acids, *e.g.* alanine or glutaminic acid, or certain ammonium salts (ammonium tartrate or succinate), or a combination of one ammonium salt and one amino-acid was added, the larvae grew to full size and produced pupae and normal flies. The experiments are certainly very interesting, showing as they do that larvae of *Drosophila* are able to satisfy their nitrogen requirements by feeding on very simple nitrogenous compounds. Bacteria were not, however, excluded from the experiments, and it is possible that they played an important part in the nutrition of the larvae.

Bogdanow (1908) bred larvae of *Calliphora* on a medium composed of peptone, meat extract, starch and mineral salts, and found that this food was unsuitable if sterile, but the addition of trypsin was followed by a very rapid growth of larvae. The action of trypsin in this case may be due, perhaps, to

its rôle in the digestion of the food, but it may also serve as a direct food stimulating growth.

A very interesting case of the effect of nitrogen in insect food is presented by honey-bees. Larvae of all castes, *i.e.* workers, drones and queens, are given identical food during the first days of their development, the food being very rich in proteins. In the later stages this kind of food is, however, only given to the queen larva, workers and drones receiving a food richer in sugars and fats, but poor in proteins. The result is that adult workers become sexless, while the queen, though bred also from the same kind of eggs, becomes able to produce eggs; the case of drones is also interesting, since they develop male genital products on a food with a reduced protein content (the differences between workers and drones depend on other, not nutritional, causes not connected with the present problem). Thus, the honey-bee adopts a highly significant variation in the diet of its offspring with the purely practical purpose of breeding the required castes, viz. workers and queens. (The literature on the subject is very extensive; the main sources of information are: Planta, 1888, Nelson, Sturtevant and Lineburg, 1922; Snodgrass, 1925; Parker, 1926; Bertholf, 1927.)

Somewhat similar phenomena can apparently be observed in other social insects, particularly in termites, where the larvae of various castes obtain different food. There are, however, no definite observations recorded in regard to this question. (In the case of ants the causes determining differentiation of castes seem to be of another order.)

Reference has already been made to the fact that food containing nitrogen stimulates propagation, but shortens the life of the individual insect. Apart, however, from the sexual activities, excess of proteins in food may in some cases be unfavourable. Bogdanow (1904), for instance, has found that adult bees (workers, *i.e.* sexless individuals) are able to live for over a month on a diet of pure honey, but that they die in four or five days if given a food containing proteins, but no sugar. Similarly, adult flies (*Calliphora*) when fed only on milk, *i.e.* on a diet very rich in proteins, die very soon. Bogdanow (1928) explains these cases as a direct toxic effect of an excess of proteins.

On the whole, it would appear from the above that nitrogen, and particularly its highest compounds, proteins, can be dispensed with by insects only in those stages in which no new tissues are formed. Neither growth nor reproduction is, on the other hand, possible without nitrogen, although it may be obtained by the insect during some previous stages of its development. This conclusion is, of course, anything but unexpected, and even perhaps too obvious to be stated. It is very desirable that future work on nitrogen in insect dietetics should be concentrated on the determination of the value of various groups of nitrogenous compounds.

(*b*) Carbohydrates.

Carbohydrates can serve as an exclusive food for some adult insects. Several examples have already been quoted (see p. 309), but some more may usefully be added here. Glaser (1923), in his experiments with adult house-flies, found that sugar or some form of starch that can be assimilated is an important factor in the longevity of the flies. In Vinokurov's (1922) experiments with the same insect adult flies were able to live on a diet of pure sugar for 11·9 to 19·4 days; although without food they died within very few days. Even pure sugar thus represents a food capable of supporting an adult fly for a considerable time. Similarly, adult beetles, *Bruchus quadrimaculatus*, live

longer on sugar water than without any food, or when receiving only pure water (Larson and Fischer, 1925).

Guyénot (1917) bred larvae and adults of *Drosophila ampelophila* on an artificial medium containing peptone and mineral salts. When carbohydrates were added to the medium, it was found that dextrine, glycogen and sugars (dextrose, laevulose, glucose) do not serve for the formation of fat reserves in the larvae, but adult flies live on the food with sugars longer than without them. This again proves that carbohydrates are an important factor in the longevity of adult insects. Indeed, it was pointed out above that a diet containing proteins but no sugar can be fatal for adult honey-bees (Bogdanow, 1904; see p. 311).

The effect of proteins in stimulating the development of genital products seems clear, but there is some evidence that carbohydrates also are not without importance in this respect. For instance, the egg-production of the beetles, *Bruchus quadrimaculatus*, increases by about 50% when they are fed on sugar water, as against the number produced by the beetles receiving no food, and by some 20% as against those receiving pure water (Larson and Fischer, 1925). The problem, however, is somewhat complicated, since in the experiments of Guyénot (1917) just quoted, although the oviposition of adult *Drosophila* is more abundant on a diet containing sugars than without them, this is only so during the first days. Moreover, the eggs are unable to develop. This suggests the possibility that sugars simply stimulate oviposition, even though the eggs are not fully developed.

As regards the relative food value of various carbohydrates, the only work done has been in connection with the honey-bee. Phillips (1927) arranged an extensive series of experiments to test the food value of different carbohydrates for adult bees, by feeding them on pure carbohydrates and comparing the length of life of each of them with the length of life on pure water. The bees lived from 1·7 to 4 days without any food; but the average length of life on glucose was 8·3, on laevulose 8·9, on sucrose 7·6, on maltose 6·9, on trehalose 8 days. On many other carbohydrates the bees lived no longer than did bees without food, as they were unable to utilise them.

Similar experiments were made by Bertholf (1927) with the larvae of the honey-bee, and the results show that sucrose has the greatest life-sustaining value, the length of life of the larvae fed on it increasing 7·5 times as against those fed on water only. Following this, came in order laevulose (with the ratio 4·7), maltose (4·3), melezitose (4·3), dextrose (4·0), trehalose (3·1), dextrin (2·9), galactose (1·9), lactose (1·7), glycogen (1·1) and starch (0·9). Glycogen and starch, therefore, had no more food value than distilled water. This was due to the lack of the corresponding enzymes.

(*c*) Fats.

The information on the value of fats in insect nutrition is restricted to a single observation by Guyénot (1917) on *Drosophila ampelophila*. When fats (butter, tributyrine, triolein, tristearin, tripalmitin, triolein, etc.) were added to the usual nutritive medium (peptone and salts) the larvae failed to develop normally, although a certain quantity of fat was absorbed and even served for the formation of the adipose tissue.

(*d*) Mineral Elements.

Data on the importance of mineral elements in insect diet are also very meagre.

Bogdanow (1908) when breeding larvae of *Calliphora* on an artificial medium consisting of peptone, meat extract and starch added also some salts of calcium, magnesium, potassium, iron and phosphorus, and he records that the addition of salts had some effect; but the results were rather contradictory; no particularly good effect from the addition of salts was ever noticed.

Loeb (1915*a*) raised five successive generations of perfectly normal *Drosophila* on an artificial medium consisting of grape sugar, cane sugar, ammonium tartrate, citric acid, dipotassium-hydrogen phosphate, magnesium sulphate and water. The experiments proved that sodium and calcium chlorides are not absolutely necessary. Control experiments showed that without either potassium or phosphoric acid larvae cannot be raised. No flies could, moreover, be raised when sodium was substituted for potassium. Without magnesium, *i.e.* only with potassium and phosphoric acid, occasionally a few flies developed. The number raised was increased by the addition of magnesium sulphate.

Guyénot (1917), when raising *Drosophila ampelophila* on a completely artificial diet (see below, p. 319) including several salts, found that an addition of extra salts of iron, or of manganese, produced no special results.

The influence of iodine on the development of the caterpillars of *Deilephila euphorbiae* has been studied by Gedroyć (1923). In two experiments the author observed an acceleration of the pupation, as compared with the controls. On the contrary, in the third experiment, in which the caterpillars used were two to four days younger than in the preceding experiments, the larval period was even slightly prolonged in the iodine material. The author concludes that the influence of iodine depends on the age of the insect used in the experiments, but the experiments were conducted with too small a number of the insects (five in each experiment) to justify any definite conclusions.

Cavazza (1913, 1913*a*, 1917) made a series of interesting experiments with feeding silkworms on mulberry leaves sprayed with various chemicals, and observing the effects both as regards the development of the silkworms fed on the leaves and on their progeny. All substances experimented with (caustic potash, hydrochloric acid, potassium chloride, ferrous sulphate, mercury sublimate) resulted in a reduction of the body-weight of the larvae. Some substances (hydrochloric acid, cobalt chloride) may result in an increase in the number of moults, but only when the concentration used is too strong. Acids generally resulted in the increase of the larval and the pupal period. As with caterpillars, all the substances used resulted in a reduction in the weight of pupae; in some cases an increase in the weight of adults was observed. It is interesting to note that no connection was detected between the effect of chemicals on the larvae during their development and the egg-production of the resulting moths. Thus ferrous chloride, ferrous sulphate, copper sulphate and caustic soda produced a great mortality amongst the larvae (86–98%), but the egg-production of the surviving moths increased; potash also increased the fecundity of the adults, but hydrochloric acid, potassium chloride, mercuric chloride and cobalt chloride reduced the number of eggs laid. The treatment has also some apparent influence on the percentage of sexes in the next generation. The normal proportion is 100·5 males to 100 females, but in the experiments, the following numbers of males to 100 females were obtained: caustic potassium, 150; caustic soda, 133; ferrous sulphate, 110.

Reznitchenko (1927) determined the influence of calcium and potassium on the development of *Drosophila melanogaster*, and the result was that calcium and potassium chlorides added to the normal food do not retard the develop-

ment of the larvae, as compared with the controls, except in high concentrations. Development on an artificial medium free of calcium was normal.

Linden (1899) experimented with breeding larvae of *Vanessa urticae* with nettle leaves dipped into solutions of various chemicals, and observed that ferrous albuminate and silver-caseinate had a stimulating effect on the growth of caterpillars. The author, however, admits that the effect may have been produced not by the metals, but by the proteins.

The influence of lead on the development of caterpillars of *Smerinthus ocellatus* was demonstrated by Garrett and Garrett (1922), who bred the caterpillars on apple twigs treated with lead nitrate. The insects ate more freely, grew more rapidly and pupated about a fortnight earlier than the controls, the pupae being heavier than in the latter case. Confirmatory results have been obtained with caterpillars of other moths.

Lead nitrate has also been proved to be the cause of melanistic forms of Lepidoptera in the industrial areas. The experiments were arranged by Harrison and Garrett (1926) on larvae of *Selenia bilunaria*, which were fed on hawthorn watered with lead nitrate solution, and this resulted in a large proportion of melanistic forms. Experiments with the same insect and manganese sulphate also produced melanistic forms.

Another instance of the probable influence of mineral elements in food on pigments of Lepidoptera is offered by Burgeff (1910), who suggested that brown varieties of the usually red species of *Zygaena* may be due to the presence of iron in the soils of certain localities where these variations occur. No experimental tests have yet been made to check this interesting suggestion.

A special case of influence of mineral elements of food on insects is offered by observed effects produced on Aphids feeding on plants receiving certain salt solutions. Clarke (1903) was, apparently, the first to note that in Rose Aphids (*Nectarophora rosae*) bred on rose cuttings placed in sand moistened with solutions of $MgCl_2$, $MgSO_4$, K_3PO_4 and NaH_2PO_4 and with distilled water, there were differences in the percentages of individuals acquiring fully developed wings. Only 2 to 3% of the individuals were winged in the case of water and phosphates, but from 73 to 92% were winged on cuttings treated with magnesium salts. These results were confirmed by Shinji (1918), Haviland (1921) and Neiils (1912). Shinji experimented with a number of substances and found that the salts of the alkalis (Na, Cl, K, etc.) and alkaline earths (Ca, Br, but not Mg) may be classified as non-wing-developing substances, while the salts of the heavy metals and of magnesium belong to the wing-developing substances. The amount of magnesium salts needed to produce winged Aphids is very small, *e.g.* m/100 solution of magnesium sulphate. The results obtained by the above-named authors were contradicted by L. Ackerman (1926), who experimented with *Rhopalosiphum prunifoliae* reared on oat seedlings growing in various salt solutions, and came to the conclusion that wing-production has no connection with the salts in the water obtained by plants (see also Brittain, 1922; Mason, 1922; Wadley, 1923; Woodworth, 1908).

(*e*) Vitamins.

Recent advances in the study of the rôle of vitamins in the nutrition of man and higher animals could not fail to induce investigators to try to elucidate the possible value of vitamins in the nutrition of insects. It was only natural that the same principles and methods should be applied to the studies on insects, as those adopted in the case of higher animals. This may be one of the causes of the rather contradictory results so far obtained. Indeed, it has been

assumed by all workers that vitamins required by higher animals and by insects must be the same, and only vitamins from the sources usual in the work on higher animals have been tested. The differences in the physiology of insects and higher animals are, however, so deep, that it is permissible to hazard the suggestion that the vitamins required by insects may be essentially different from those necessary for the higher animals, and that their sources may be also very different. Thus, it would seem that, instead of testing the influence on insects of known vitamins of higher animals, it might be of more interest to try to separate vitamins specific for insects, if they exist. They may prove to be identical with those already known, and in some cases (insects feeding on flour, see below) they apparently are, but this should not be assumed beforehand. Further, the diets of various insects are very different from each other, and it is apparent that their vitamin requirements may differ very widely. Any generalisations should therefore be avoided until many more facts have been accumulated.

A very important possible reason for the contradictory character of the conclusions arrived at by different authors with regard to the value of vitamins in insect nutrition, may lie in the fact that many, practically all, have overlooked a possible source of vitamins in the symbiotic micro-organisms living inside the bodies, and even the cells, of insects (Portier, 1919). If these symbionts actually represent a source of vitamins, it would be easy to understand that breeding an insect, not previously sterilised to ensure that no micro-organisms remain in it, on a diet devoid of vitamins, cannot produce decisive results. In a very few cases sterile insects have been used in experiments, but even in these cases it is not always clear whether any intracellular symbionts were present. It appears that the sterilisation of the digestive tract is usually considered sufficient to remove the possible source of vitamins from an insect body, but this is scarcely so.

Since the problem of the value of vitamins in insect nutrition is relatively very novel, and no summaries of the literature dealing with them have ever been published, it seems desirable to present a rather full review of the main papers on the subject.

Most of the work done on the problem refers to the fly *Drosophila*, which feeds on yeast developing in fermenting fruit and similar substances. Very extensive and carefully arranged experiments by Guyénot (1913; particularly 1917) with breeding *Drosophila ampelophila* on various synthetic media, have shown very definitely that no artificial food is complete unless the substances contained in the filtered autolysate of yeast are added to it. A series of experiments was arranged for isolating the active elements of the autolysate, but without success. It is concluded that it is a vitamin of yeast the absence of which retards the development of larvae and causes their death. (In a previous paper by Delcourt and Guyénot, 1910, the authors found that *Drosophila* can develop on artificial food without yeast, but the later experiments by Guyénot, recorded above, were arranged more carefully and the results are more convincing.) Northrop (1926) recorded 230 successive generations of *Drosophila* freed from micro-organisms and bred on aseptic dead yeast, but this is hardly a proof that yeast vitamins are not required, since it was not proved that the methods applied for the sterilisation of yeast were sufficient to ensure the destruction of the yeast vitamin. Definite experiments with vitamins of known substances in the food of *Drosophila* were arranged by Bacot and Harden (1922), and the results showed that the insect requires for its complete development the presence of vitamin B (yeast), but not that of the vitamin C (lemon juice). Preliminary results of experiments with the vitamin A (butter) indicated that the insect is

certainly able to develop in the presence of only very small amounts of vitamin A, if not in its absence. Glaser (1924) attempted to summarise the literature on the value of micro-organisms in insect nutrition, and his final conclusion is that micro-organisms may be one of the principal sources of the accessory growth factors of the larvae of some flies. This assumption must not, however, be regarded as proved. This author succeeded in breeding two generations of *Drosophila* under perfectly sterile conditions.

An interesting point has been raised by Loeb and Northrop (1917*a*), who observed that, while the larvae of *Drosophila* cannot grow on glucose agar unless yeast is added, the adult flies developed on pure glucose agar just as well as on glucose agar with yeast. This means that the adult may be able to dispense with vitamins which are necessary for the larval development.

Another insect which has served as an object for experiments on vitamin is the flesh-fly *Calliphora*, studied by Wollman, who published a series of papers on the results. He has bred (1919) sterilised larvae of *Calliphora vomitoria* on brains sterilised at 130° C. for 45 minutes. Contrary to expectations, the larvae developed much better than if bred on meat sterilised at 115° C. In order to test whether the method of sterilising brains guaranteed the destruction of vitamins, feeding experiments were made (1919*a*) on rats, some of which were given rice and cerebellum sterilised at 134° C., while others received, in addition, some larvae of *Calliphora* bred on the same diet. The results showed (*a*) that not all the vitamins are destroyed at 134° C., and (*b*) that the larvae contained an appreciable quantity of vitamins. Since it seemed to the author impossible to assume that the larvae could produce vitamins, he concluded that they are able to concentrate them while feeding on a diet very poor in vitamins. In still later experiments (1921, 1922) the same author arrived at the conclusion that vitamins in food are not absolutely necessary for the development of *Calliphora*. The facts, however, are not perfectly convincing, and in particular it is doubtful whether all possible steps have been taken to eliminate *all* symbiotic micro-organisms from the body of the insects.

The same author (Wollman, 1926) has done some experiments on the cockroach, *Blattella germanica*. Egg-capsules of cockroaches were sterilised by immersion in sublimate solution and the insects, fed from hatching on sterilised food, developed normally, producing a continuous series of generations for five years. This proves, in the author's opinion, that they can dispense with vitamins, but it must be remarked that the method of sterilising whole egg-capsules does not ensure a complete elimination of symbiotic micro-organisms, which may be present not only on the shells of individual eggs, but even inside them.

Cockroaches (the same species and *Blatta orientalis*) were bred also by Zabinski on synthetic diets with, and without, vitamins, but the results are contradictory; in the first report (1926) no difference was observed in the rate of growth on different diets; in the second (1928) the author says that the rate of growth on a food without vitamins was slower than that on a complete diet with vitamins; in the third paper (1928*a*, published simultaneously with the second in the same journal) he states definitely that there is no acceleration of growth if a complete synthetic diet is supplemented by small quantity of butter, yeast or extract of bran, or if the food is subjected to ultra-violet rays.

Some suggestive data have been obtained from studies on the vitamin requirements of insects feeding on flour. The paper by Richardson (1926) on the Mediterranean flour moth (*Ephestia kuehniella*) is particularly interesting. The results of his very carefully arranged experiments were as follows. In

entire wheat flour extracted with chloroform, only a few larvae developed into moths. More effective extraction removed the growth-promoting substance so completely that all the larvae died at an early age, but if the extracted material was replaced, the larvae grew normally. Similarly, when entire wheat, extracted with chloroform or with anhydrous ether, was supplemented with an ether extract of egg-yolk, larvae grew normally. The ether-soluble part of butter, as a supplement, did not permit growth. Butter oil permitted growth at somewhat reduced rate. Highly milled patent wheat flour caused a retardation in the growth of larvae, and the emerging adults only attained a weight equal to between 50 and 60% of the normal. The addition, however, to the flour of the alcoholic extract of yeast increased the rate of growth and the weight of the resulting moths. On the strength of these experiments it is concluded that ether and chloroform both remove from the entire wheat flour a substance, or substances, which are similar to, or identical with, vitamin A as understood in mammalian nutrition. The same vitamin A contained in egg-yolk and butter promotes the growth of larvae. Deficiency of highly milled flour for growth purposes depends, at least partly, on the low concentration of vitamin B, since the addition of yeast extract improves the growth value. The normal source of vitamin B for the larvae appears to reside largely, but not entirely, in the embryo of the wheat kernel.

The importance of the wheat germ as a source of vitamin B is further suggested by the habit of harvesting ants (*Messor*), which eat out the germ from the seeds of grasses collected for storage (Emery, 1912).

Amongst other insects feeding on flour, the beetle *Tribolium confusum* has been studied by Chapman (1924), who bred the insects on a number of definite synthetic media. A diet containing starch, wheat gluten, wheat germ, vitamin B in dextrin and salts gave almost the same rate of development as the normal food. A diet of the same kind, but without the wheat germ, produced an almost normal development up to the time of pupation, when, however, all the larvae died. The vitamin extracted from the wheat germ did not give the results that the wheat germ gives, so that the latter must be of importance also as a source of protein.

Larvae of *Tenebrio molitor*, bred by Portier (1919) on flour sterilised at 130° C., developed at least as rapidly as the controls, and the author concludes that the source of vitamins is actually within the insect in the shape of symbiotic intracellular organisms. Passerini (1925) found that the larvae of this beetle do not develop on wheat flour made of grain deprived of husks, but they develop rapidly if even a small amount of husks, or other foodstuffs containing vitamins, is added.

Adult bees can survive for a whole winter on pure honey, in which so far no vitamins are known (Phillips, 1927), but there is no growth or any tissue-building during that period.

Experiments with caterpillars were made by K. Abderhalden (1919), who fed those of *Deilephila euphorbiae* on plants sprayed with yeast extract and obtained very large moths; and by Kopeć (1927), in whose experiments larvae of *Lymantria dispar* fed on branches of plants sprayed with cream (vitamin A) and water extract of wheat bran (vitamin B) produced smaller pupae than the normal.

It is not impossible that the failure of Atkin and Bacot (1917) to breed larvae of the mosquito *Stegomyia fasciata* in the absence of bacteria and yeast may be due to these micro-organisms supplying the necessary vitamins. The problem, however, was not studied from this point of view.

To conclude, the evidence, as has been stated at the beginning of the section, is somewhat confusing, but at least in one case, that of insects feeding on flour, there can be no doubt that for some species of insects the value of vitamins is just as great as for the higher animals. Much more numerous and more exact studies are essential for the elucidation of this interesting problem.

(*f*) Endocrine Glands and their Secretions.

As in the case of vitamins, the progress of the endocrinology of higher animals and man resulted in some attempts to study the effect of feeding mammalian endocrine glands, or products of their secretion, to insects. The main idea underlying most of these experiments was to find out whether the endocrine glands and their products would have the same influence on the development of insects, which themselves have no such glands,* as on mammals. Thus the interest of the problem belongs entirely to the sphere of general physiology. It is hardly relevant to the study of the physiology of insects, since mammalian endocrine glands and their products are, of course, never present in the normal diet of any insect. It is proposed therefore only to survey the literature on the subject very briefly. For details, the original papers should be consulted. It is believed that the list of references is practically complete.

The bulk of the experiments made with feeding various insects either directly on mammalian endocrine glands (larvae of flesh flies, etc.), or on their extracts, or on respective commercial preparations (thyreoidin, adrenalin, etc.), had distinctly negative or, at least, indefinite results. (Cotronei, 1918, 1923, larvae of Diptera on canine thyroid and silkworms on endothyreoidin; Kahn, 1921, larvae of *Corethra* on pulverised thyroid and on artificial iodine-protein preparation, larvae of Ephemerid *Ecdyurus forcipula* on iodine-protein preparation, and larvae of *Tenebrio molitor* on thyroid or artificial preparation; Patterson, 1925, 1925*a*, larvae of *Sarcophaga* and *Calliphora* on hypophisis; Remy, 1923, larvae of *Plagiodera armoraciae* and of *Bombyx mori* on thyreoidin; K. Abderhalden, 1919, larvae of *Deilephila euphorbiae* on thyroid, suprarenal gland, thymus, ovaria, etc.; Romeis und Dobkiewicz, 1920, larvae of *Calliphora vomitoria*; Reznitschenko, 1926, 1927, *Drosophila melanogaster*; Gedroyć, 1923, larvae of *Deilephila euphorbiae* on iodine; Kopeć, 1924*a*, 1926, caterpillars of *Lymantria dispar* on thyreoidin.)

More or less positive results have only been obtained in a very few cases, as follows. Kunkel (1918) bred larvae of *Lucilia* on thyroid and thymus, and, while thyroid retarded the growth and reduced the weight of pupae, the thymus tended to increase the weight. Terao and Wakamori (1924) when feeding silkworms on mulberry leaves sprinkled with a commercial preparation of thyroid, found that the growth was affected unfavourably, but the larvae completed their development and the amount of silk produced by them was greater than in the case of controls, and the adults laid more eggs. Zavrel (1927) bred the larvae of two Chironomidae on vegetable food with, and without, thyroid, and found that the larvae grew faster with thyroid. Farkas and Tangl (1926) observed that adrenalin accelerated the development of silkworms. In Bogdanow's experiments (1928) flies (*Calliphora*) bred on thyroid were normal, except that they were slightly larger than the controls.

* It may be mentioned here that Kopeć (1922, 1926) advanced a hypothesis that the brain of insects may be a gland with an inner secretion, but this view was opposed by Gedroyć (1923). Geyer (1913) thought that genital glands in Lepidoptera may be of specific influence on metabolism.

It will be seen that the bulk of the evidence is definitely against the view that mammalian endocrine glands, or their products, can exercise any positive influence on the development of insects. The few cases of apparently positive results may be explained on entirely different grounds, *e.g.* by an increase in the general nutritive value of the food treated or given.

It is, perhaps, worth stressing once more that the problem has scarcely any interest from the point of view of the normal physiology of insects.

(*g*) Complete Artificial Foods.

Since experimental work on insect dietetics should be conducted on strictly definite foods enabling exact modifications to be made, it may be useful to present here a few examples of artificial media used in previous experiments.

A complete synthetic food for breeding cockroaches was composed by Zabinski (1928) from 18 parts of ovalbumine, 56 parts of starch, 20 parts of saccharose, 2·3 parts of agar and 3·7 parts of the McCalloum and Simmonds salts mixture; the addition of vitamins rendered the food complete (see p. 316).

Other known synthetic foods all refer to *Drosophila*. The first complete receipt given by Guyénot (1917) is as follows :—

	Grams.
Peptone	1
Glucose	1·5
Tributyrine	2 drops
Potassium chloride	0·2
Trisodium phosphate	0·2
Magnesium chloride	0·4
Monocalcium phosphate	0·1
Ferrous chloride	0·01
Acetic acid	1 drop

Distilled water to make 100 cm. cb.

(Addition of yeast extract makes the food complete.)

Loeb (1915*a*) offered the following artificial food for the same insect :—

	Grams.
Grape sugar	0·5
Cane sugar	0·5
Ammonium tartrate	0·1
Citric acid	0·05
K_2HPO_4	0·005
$MgSO_4$	0·005
Water	3 cm. cb.

The latest receipt for an artificial medium for *Drosophila* is that given by Pearl (1926), viz. :—

Solution A.

	Grams.
Cane sugar	500
$KNaC_4H_4O_6{\cdot}4H_2O$	50
$(NH_4)_2SO_4$	12
$MgSO_4{\cdot}7H_2O$	3
$CaCl_2$	1·5

Water to make 3000 cm. cb.

Solution B.	Grams.
Agar agar	135
Tartaric acid ($C_4H_6O_6$)	30
HK_2PO_4	6
Water to make 3000 cm. cb.	

Equal parts of the two solutions are then mixed.

VII. BIBLIOGRAPHY.

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A REVISION OF THE EUROPEAN BEES ALLIED TO *PSITHYRUS QUADRICOLOR*, LEPELETIER (HYMENOPTERA, *BOMBIDAE*)

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Plate XI.

It has for some time been doubtful * how many species could be distinguished within this group of *Psithyrus*. There has been a tendency (*e.g.* Pérez, 1884, p. 266) to suspect that all the European forms may be only varieties of one species, and in any case it was not known that the supposed species differed except in their colour-patterns. These facts have led me to examine as much material as I could obtain of these bees, and the present paper distinguishes the five species into which I believe the group must be divided and also describes their colour-variation, notes on two allied non-European species being added.

I am indebted to the following gentlemen for lending me specimens from either their own or from the public collections of which they are guardians: Monsieur A. Ball (Belgian Nat. Mus.), Monsieur L. Berland (Paris Nat. Hist. Mus.), Mr. A. E. Bradley, Mr. H. Britten (Manchester Mus.), Dr. R. Forsius, Mr. A. H. Hamm, Konservator L. Natvig (Oslo Mus.), Dr. R. C. L. Perkins, Mr. V. B. Popov (Leningrad), Prof. E. B. Poulton (Hope Mus., Oxford), Dr. J. Ritchie (Royal Scottish Mus.), Konservator T. Soot-Ryen (Tromsoe Mus.), Mr. A. W. Stelfox (Nat. Mus., Ireland), and Dr. J. Waterston (Brit. Mus.). I am also indebted to Prof. E. S. Goodrich for the laboratory facilities of the department of Zoology and Comparative Anatomy at Oxford, where nearly all the work was done. Without the help of all these gentlemen it would have been impossible to write the present paper.

In describing the variations of humblebees some forms are called "races," others "varieties." The former term is applied to *populations* inhabiting definite, usually continuous, areas and characterised by peculiarities of sculpture, hair-length or average colour-pattern. Varieties, on the other hand, occur more or less sporadically, and the term is applied to all *individuals* having a particular colour-pattern. In certain cases a race may partly be defined by the proportion of some variety to the type-form in that population.

Definition of the *Ps. quadricolor* Group.

I have summarised the differences between the British species of *Psithyrus* in another paper (Richards, 1927) on the specific differences of British humblebees. For explanation of the terms used in the present definition, reference must be made to my other paper.

Female. The main keel of the mandibles is much narrowed (often interrupted) just before the margin; the tubercles of the labrum are flattened and not much projecting and not at all fused with the lamella; the hind metatarsus is narrower than the apex of the hind tibia; the sixth tergite is not

* A valuable paper dealing with the group (Popov, 1927) appeared while my work was in progress.

sufficiently punctured to appear very dull; the sixth sternite has two rather small, convergent, apical callosities, and has its extreme apex produced into a hook.

Male. The seventh sternite has two distinct apical hair-tufts; the eighth sternite has the basal projection much longer than broad, the apical production of the sternite parallel-sided, with its apex rounded; the volsella of the genitalia has rounded basal and median lobes, each bearing tufts of closely-set hairs; the apical part of the volsella is narrow and parallel-sided and ends in a hair-tuft; the inwardly directed process of the squama is largely membranous; the sagittae have a median ventral tooth.

The N. American *Ps. fernaldae*, Frankl., and the Tibetan species mentioned later in the present paper also belong to the group, which Frison (1927, p. 70) has described as subgenus *Fernaldaepsithyrus*.

Characters by which the Species may be Distinguished.

Important distinctions may be found in the structure of the male genitalia. The specific differences are, of course, small and to some extent variable, but the study of a large number of balsam mounts has convinced me that they are real. Intermediate forms occur only rarely and in each species the modal type of genitalia is different. The structure can often be sufficiently made out in the dried genitalia gummed on a card, but diagnosis is most certain if the genitalia are boiled in KOH and are examined under water or in balsam mounts.

The main differences between the species are tabulated below. *Ps. meridionalis*, n. sp., and *Ps. skorikovi*, Popov, are omitted, since they scarcely differ from *Ps. quadricolor*, Lep., and *Ps. norvegicus*, Sparre-Schneider, respectively.

Character.	*sylvestris.*	*lissonirus.*	*norvegicus.*	*quadricolor.*
		Females.		
Size.	Small.	Small.	Large.	Large.
Development of the labral lamella.	Slight.	Slight.	Strong.	Slight.
Malar space.	Long.	Long.	Very long.	Long.
Puncturation of clypeus.	Sparse.	Sparse.	Dense and strong.	Sparse.
Scape of antenna.	Bare, shining.	Dull, hairy.	Dull, hairy.	Dull, hairy.
Fifth tergite.	More punctured.	Less.	Less.	Less.
Sixth tergite.	Duller.	More shining.	More shining, often keeled.	More shining.
		Males.		
Scape of antenna.	Less hairy.	More hairy.	More hairy.	More hairy.
Third antennal joint.	Rarely much shorter than fifth.	Scarcely shorter than fifth.	Much shorter than fifth.	Scarcely shorter than fifth.
Sixth sternite.	With a bilobed apical projection.	Usually without a projection.	Often without a projection.	Without a projection.
Hairs on the inside of base of volsella.	Not very dense.	Not very dense.	Very dense.	Not very dense.
Basal lobe of volsella.	Not much developed.	Not much developed.	Strongly developed.	Little developed.
External hairs of volsella.	Short.	Rather short.	Rather short.	Very long.
Squama.	Broad, rather incurved.	Narrow, little incurved.	Broad, rather incurved.	Broad, much incurved.

Systematic Account of the Species.

Psithyrus quadricolor, Lep.

Psithyrus quadricolor, Lepeletier de St. Fargeau (1832), p. 377, (1841), p. 428; Kriechbaumer (1854), p. 185 (vars. 1 and 2 of both sexes), and p. 186 (specimens from Sweden); Pérez (1884), p. 266 (in part), (1890), p. 23; Frionnet (1901), pp. 179–81, and p. 183 (in part). *P. quadricolor* var. *intercalarius*, Mueller (1913), p. 122. *Apathus quadricolor*, Thomson (1870), p. 260 (probably). *Psithyrus globosus*, Eversmann (1852), p. 126; Pérez (1884), p. 269; Sahlberg (1889), p. 172; Lie-Pettersen (1900), p. 17; Aurivillius (1903), pp. 156–7; Sparre-Schneider (1917), pp. 38–9; Forsius and Nordstroem (1921), p. 76; Jørgensen (1921), p. 255 (? in part only); Popov (1927), pp. 272–3. *Apathus globosus*, Thomson (1872), p. 48; Strand (1898), p. 84. *Psithyrus quadricolor* var. *globosus*, Pérez (1890), p. 23; Jørgensen (1918), p. 119, and pp. 122–3 (? in part only). *Psithyrus suaveolens*, Wahlberg (1851), p. 232, (1854), p. 206, (1857), p. 134; Handlirsch (1888), p. 247; Dalla Torre (1896), p. 573; Friese (1902), p. 484.

I do not transcribe Lepeletier's original Latin diagnosis, since that includes also the distinct species *Ps. sylvestris*, Lep.

Original description :—" Tête noire; une touffe de poils jaunes sur le vertex. Corselet noir; sa partie antérieure portant une large bande jaune qui descend des côtés jusqu'au sternum exclusivement; bord postérieur de l'écusson jaune. Premier segment de l'abdomen noir, ayant chaque côté une forte touffe de poils jaunes; le deuxième noir; le troisième blanc, noir dans son milieu; quatrième blanc; le cinquième et l'anus roux. Cuisse et jambes noires; tarses noires, mêlées de roux en dessus, entièrement roux en dessous. Ailes transparentes, enfumées, surtout au bord postérieur. Femelle. Hab. Les Pyrénées."

This description agrees perfectly with the female of a species found in Southern and Central France and in Northern Europe.

The synonomy of the names *globosus*, *suaveolens* and *intercalarius* must be considered here. The following is the original description of *globosus* by Eversmann (1852), p. 126 :

" Ps. hirsutus, ater, abdomine subgloboso, ano rufescente; thorace antice fascia flava; alis leviter infuscatis. Fem. Minor praecedente (i.e. *Ps. rupestris*); cognoscitur abdomine subgloboso, atro, segmentis tribus ultimis (3–5) rufescenti-villosis. Caput et pedes atro-hirti, vertex pilis nonnullis flavis immixtis. Hab. in promont. Uralensibus."

The species which occurs in Germany and Austria, and to which the name *globosus* is usually given, rarely has any yellow on the thorax in the female, probably never a well-developed collar; nor has it any yellow hairs on its vertex. On the other hand, a species answering to Eversmann's description, except that careful examination shows that the hairs of the fourth tergite are nearly always considerably paler than those of the third and fifth, occurs in Scandinavia. Such specimens in their large size and in their colour-pattern agree closely with varieties of *Ps. quadricolor* from France in which the red hairs are rather more numerous than usual. I therefore regard *globosus*, Ev., as a synonym of *quadricolor*, Lep. Mr. Popov has examined the type of *Ps. globosus*, Eversm., and has been kind enough to send me a female and three males from Russian localities. There is a fairly close agreement between these Russian specimens and the Scandinavian ones I have examined. I am not yet, however, absolutely convinced that the careful study of abundant Russian material would not show that there was a special Russian race to which the name *globosus* would be properly applicable. For the present I keep the name *globosus* for both the Russian and the Scandinavian races; if these races after-

wards prove to be distinct, the name *suaveolens*, Wahlbg., is available for the latter race.

The following is Wahlberg's (1851, p. 232) original description of *Ps. suaveolens* :—

" Oblongus, hirsutus, ater, thorace antice sordide flavo, ano fulvescente, alis apice infuscatis. Mas, femina long. 5–6 lin. Habitat in floribus carduorum ad Gusum Ostrogothiae et circa Holmiam haud raro, praesertim versus autumnum. In copula captus. Har varit förvexlad med *Ps. campestris*, men liknar till staturen närmare *Ps. vestalis*. Skiljes från den forra, genom bredare och mindre convex kroppsform samt röd, ej grongul, anahärighet, från den sednare genom mindre storlek och röd, ej hvit, härihget på abdomens opets, från båda genom sin rosenlukt."

This description, again, agrees with the Scandinavian race of *Ps. quadricolor*. Handlirsch (1888, p. 247) describes a male sent him by Morawitz, labelled *suaveolens*, which was evidently a *quadricolor*.

Mueller's description (1913, p. 122) of his variety *intercalarius* is as follows :—

" Weibchen wie die Stammform mit breiten, gelben Collare, aber Segmente 3–5 blassrot behaart, und zwar an den Seiten am Stärksten; das hakenförmig gekrümmte Endsegment fast nackt, schwarz.

" Männchen gleichfalls der Stammform ähnlich, weicht aber in der Färbung der letzten Abdomensegmente wesentlich ab. Segmente 3–4 gelb, die übrigen leuchtend rostrot behaart, an den Seiten mit eingemischten gelblichen Haaren. Fundort: Norrköping, Südschweden."

This description agrees perfectly with the Scandinavian race of *Ps. quadricolor*, while the red hairs of the fifth tergite show that it is not a variety of *Ps. sylvestris*, the species probably implied by Mueller's " *quadricolor*."

Diagnostic characters * :—*Ps. quadricolor* is distinguished from all bees of this group except *Ps. meridionalis* (q. v.) by the red hairs of the fifth tergite. Apparently the admixture of even a few black hairs on this segment is very rare (see account of variation) and is only found in the male. The female is usually of large size, especially in the southern races. The scape of the antennae is hairy and quite dull. In the male the sixth sternite has no apical callosity. The external hairs of the volsella are very long (as in *Ps. meridionalis*, fig. 5) and the squama is more or less strongly incurved (see fig. 2*c*).

Colour variation. Female. The typical form is found in the Pyrenees :— Black †; a large tuft of yellow hairs on the vertex, rarely black-mixed; a very broad yellow collar, more often than not continued below the anterior spiracle; often numerous yellow hairs on the scutellum, which is sometimes yellow to the naked eye; 1 black, nearly always yellow laterally; 2 black; 3 black, apically narrowly white on the disc, more than half white at its sides; 4 white; 5 pale red; hairs of the legs black.

According to Pérez (1884, p. 266) the white of 3 and 4 may be replaced wholly or in part by red. I have examined ten females, from various Pyrenaean localities, in the Pérez coll. at the Paris Mus. and I find that, at the most, the

* Only the more important characters are mentioned here, especially those which are shared by no, or only a few, other species. For less distinctive characters the tabulation on p. 346 may be consulted.

† Colour, in the descriptions, refers to the hairs; numbers refer to the abdominal tergites.

base only of 3 is red and sometimes the sides of 4; this, however, would appear to be rare.

1. There may be no yellow on 1 and very little on the scutellum.

2. Race **arvernicus**, n. race. In the Auvergne (Puy-de-Dôme) occurs a form in which there is less yellow. In these, there is, on the average, a less-developed pale tuft on the vertex; the collar is not continued below the anterior spiracle; there are, on the average, fewer yellow hairs on the scutellum and on 1; there is less black on 3, there being, as a rule, only a basal discal patch, while the pale hairs are nearly always reddish, especially at the sides; 4 may also be slightly reddish. For this race, of which I captured six females at Besse-en-Chandesse in July 1926, I propose the name *arvernicus*, n. race. There are also two females in the Pérez coll. in the Paris Mus.

3. Race *globosus*, Eversm. The race occurring in Russia, Scandinavia and Finland has still less yellow and the tail is redder: the tuft on the vertex is black; collar as in *arvernicus*; no pale hairs on the scutellum or on 1; 2 black; 3 black, apically narrowly on its disc, more than half at the sides, pale red; 4 whitish red, darker on its disc; 5 pale red; tibial hairs dark; size rather smaller than in the French races. Five females from Bergen in the Tromsoe Mus., six from various Norwegian localities in the Oslo Mus., three from Vesterlund, Norway, in the British Mus., one Parikkala and one Impilaks, Finland (sent by Dr. Forsius), and one Dorpat, Esthonia, in the Pérez coll. in the Paris Mus. In one of the Bergen specimens the colour of 4 is almost as deep a red as that of 3 and 5. A female from Randøsund, 2 Aug. 1886 (Oslo Mus.), has the scutellum conspicuously yellow, a rare variation in this race. In the only Russian female I have seen (Guv. Novgorod, sent by Mr. Popov) 3 is entirely pale reddish and 4 nearly white. For this race the name *globosus*, Eversm., may be used (see remarks above, p. 347). *Intercalarius*, Mueller, is synonymous with the above. It is unfortunate that in all the collections I examined before I felt certain of the synonymy, I employed the latter name on my labels.

Male. Specimens from the Pyrenees are as follows: Black; a large yellow tuft on the vertex, usually not at all black-mixed; a yellow collar, usually very broad, and usually continued below the anterior spiracle; scutellum with enough yellow hairs to appear yellow to the naked eye; 1 yellow, with a few, rarely many, black hairs on its disc; 2 black; 3 black, apically narrowly yellowish-white to yellowish-red on its disc, broadly at its sides; 4 yellowish-white to yellowish-red; 5 pale red, sometimes with a few black hairs on its disc; 6–7 rather deeper red; hairs of the legs sometimes reddish on the dorsal surface of the posterior tibiae. (Seven males in the Paris Mus.)

A male in the Pérez coll. in the Paris Museum, without locality but evidently Pyrenaean, shows the maximum extension of black on 5 in this species. It resembles the above description except that 3 is yellow with a few black hairs on its disc, while 5 is black, red-mixed laterally and apically. The genitalia show this to be a male of *Ps. quadricolor*, Lep.

1. Geographical variation is not so marked in the males, but a careful analysis shows that the races can be distinguished by the average of their patterns.

The males occurring in the Auvergne, race *arvernicus*, n. race, are like the type-form, but in more than half the specimens the vertical tuft is mainly black; the collar is not produced below the anterior spiracle; the scutellum is usually yellow behind, but not conspicuously yellow to the naked eye; 1 usually yellow or yellow-mixed at the sides; pale hairs of 3 and 4 sometimes strongly red-tinged. In two males the apex of 3 and the whole of 4 were of a

red only slightly more yellowish than that of 5–7. I have seen eight males from the neighbourhood of Mont-Dore (Puy-de-Dôme) in the Pérez coll. in the Paris Mus.

2. One male from Bourg d'Arud, Isère, is like the type-form, but the collar is not continued below the anterior spiracle; 3 is reddish-yellow with only a few black hairs at its base; 4 yellowish-white; 5–7 red, tibial hairs reddish. Another male from the same locality is similar, but the tail is entirely pale red (paler than in *Ps. meridionalis*, n. sp.). Further material from Savoie may show that race *arvernicus* occurs there too.

3. A male from Denmark in the British Mus. is like the type-form, but there are fewer yellow hairs on the vertex; the collar is not continued below the anterior spiracle; scutellum black; 1 entirely yellow; 4 pure white, not yellowish white; 5–7 pale red; tibial hairs black. From Jørgensen's descriptions (1918, 1921), however, it would appear that much darker forms also occur. Very possibly the race *globosus*, Eversm., here overlaps *Ps. meridionalis*, n. sp.

4. The males of the race *globosus*, Eversm., are like the type-form but there are fewer yellow hairs on the vertex, sometimes very few or none; collar not continued below the anterior spiracle; rarely any yellow hairs on the scutellum; less yellow on 1, there being only a few pale hairs on its sides; pale hairs of 3 red, sometimes whitish red; 4 whitish red; 5–7 pale red; hairs of legs black. The race *arvernicus* differs in having, on the average, rather more yellow hairs in the vertical tuft, on the scutellum and at the sides of 1, and in the much less frequent occurrence of red hairs on 3 and 4.

Sometimes the black may spread so that the whole of 3 is black-mixed (1 male, Bergen, viii/01) or even entirely black, and the base of 4 is black-mixed (1 male, Bergen, viii/01). Two males in the Oslo Mus. (labelled Kristiania and Valders) have the scutellum yellow and more yellow than usual on 1.

Of this race I have examined eight males from Bergen and one from Uldum, Sylland, Norway, in the collection of the Tromsoe Mus., and, besides the two mentioned above, one other from Valders in the Oslo Mus. For the Finnish and Russian specimens see the next paragraph.

5. Five males from various localities in Finland (kindly sent by Dr. Forsius) have more yellow hairs than the Scandinavian forms. In all the vertical tuft is mainly yellow, the sides, and in one case most of the disc, of 1 are yellow. In one specimen the collar, mesopleura and most of the sides of the metanotum above the wings are mainly yellow, while in all the scutellum is yellow mixed. In four of them the pale hairs of 3 and 4 are strongly yellow tinged. In three Russian males, sent by Mr. Popov, the pattern is similar, but 3 and 4 are whiter and the scutellum has less yellow. These males are rather similar to the typical Pyrenaean form, but the female appears to resemble that of *globosus*, Eversm.

This disparity in the males suggests that *globosus*, Eversm., may be a purely Russian and Finnish race, differing from the Scandinavian; to decide this a large number of females from each area would have to be compared (cf. discussion, p. 347).

6. Handlirsch (*loc. cit.*) describes a male from St. Petersburg as follows :— Black with a yellow collar; 1–2 black; 3 dark red; 4–5 yellow; 6–7 red, otherwise like *globosus* (i.e. *meridionalis*). This specimen was labelled *suaveolens* by Morawitz.

7. It will be seen that the male of this species usually occurs in a form somewhat paralleling the var. *citrinus*, Schmdk., of *Ps. sylvestris*, Lep. In *Ps. quadricolor* males it is rare for the hairs of 3 and 4 to be pure white, though

they are never as bright yellow as those of extreme forms of *Ps. sylvestris* and they are often red-tinged.

Range. With the present imperfect knowledge of the group, the range appears to be : *Ps. quadricolor quadricolor*, Pyrenees; *Ps. quadricolor arvernicus*, Auvergne and probably Savoie; *Ps. quadricolor globosus*, Russia, Norway, Sweden, Finland, Esthonia and probably Denmark.

Psithyrus meridionalis, n. sp.

Ps. globosus, Kriechbaumer (1854), p. 187; Schenck (1867/8), p. 337; Gerstaecker (1869), p. 329, and (1872), p. 298; H. Mueller (1881), p. 590; Schmiedeknecht (1882/4), p. 409; Handlirsch (1888), p. 247; Hoffer (1889), p. 153; Friese and Dalla Torre (1894), p. 34; Frey-Gessner (1900), p. 77; Frionnet (1901), pp. 179–81, and p. 183 (in part); Schmiedeknecht (1907), pp. 141, 142; Saunders (1909), p. 84; Vogt (1909), p. 50; Frey-Gessner (1912), pp. 74–6, and p. 82; Strand (1915), p. 138; Bluethgen (1916), p. 40; Mocsary (1918), p. 102; Jørgensen (1921), p. 255 (? in part); Maidl (1922), p. 102 (probably). *Ps. quadricolor* st. *globosus*, Dalla Torre (1896), p. 569. *Ps. quadricolor* var. *globosus*, Ducke (1898), p. 141; Jørgensen (1918), p. 119 and pp. 122–3 (? in part). *Ps. campestris* var. *globosus*, Friese (1923*a*), p. 196 (probably; the name *campestris* is presumably a misprint for *quadricolor*).

Previous authors do not appear to have realised that the bee occurring in Germany, Austria and Switzerland, commonly known as *Ps. globosus*, Eversm., differs markedly in colour-pattern from Eversmann's original description, which I have transcribed on p. 347 of the present paper. There is some doubt as to whether the present form is not merely a geographical race of *Ps. quadricolor*, Lep., but even if it is, it requires a racial name. As a matter of convenience in dealing with the geographical variation of the true *Ps. quadricolor*, I treat *meridionalis* as a species, not a race. As types I choose one female and twelve males bearing the labels " Styria, Tragop Oberort, E. Graeffe " in the collection of the Tromsoe Mus.

Diagnostic characters. Almost identical in structure with *Ps. quadricolor*, Lep., for whose characters see the table on p. 346, but the average size of the female is smaller, and in the male the apex of the squama of the genitalia is often less incurved (genitalia, fig. 5). Differs, in colour, from all but uncommon varieties of the other species of the group in having yellow hairs almost or completely absent from the thorax, and also in having part of 3 and the whole of the succeeding segments uniformly pale red, 6 having short reddish hairs in the female.

Colour-variation. Female. Usual form :—Black; more than half of 3 apically and 4–5 red; tibial hairs black.

1. The amount of red on 3 varies. There may even be a few red hairs at the apex of the disc of 2, while the black of 3 is reduced to a few hairs intermixed on the base of the disc. Conversely, 3 may be only narrowly red on the apical part of the disc, though more than half red at the sides.

2. The collar may be brownish or brownish-yellow either laterally only or completely. I have seen no females with a conspicuous clear yellow collar.

Male. Black; collar rarely more than indicated by pale hairs; some, as a rule, of the apical part of 3 and the whole of 4–7, red; hind tibial hairs usually more or less red.

1. As in the female, the extension of the red hairs towards the base is variable, though in neither sex have I found any evidence that the variation is geographical. Sometimes there are a few red hairs at the apex of the disc of 2 and the black of 3 is reduced to a few hairs intermixed on the base of the disc, while in other specimens 3 is entirely black and the base of 4 is black mixed.

This leads to the extreme form * described by Vogt (1909, p. 50), from the Fichtelgebirge, in which only 7 and the apex of 6 are red.

2. The collar is frequently indicated laterally by yellow or brownish spots, or may be complete.

3. The tibial hairs are sometimes black, more often markedly red, all intermediates occurring.

Range. I have examined 10 females and 36 males of this species, including specimens from Germany, Austria, Switzerland and France (Isère). Specimens recorded by Friese (1923) from Macedonia and by Maidl (1922) from Montenegro and Albania are probably this species. For its possible occurrence in Denmark see under the preceding species. The range thus hardly overlaps that of *Ps. quadricolor.* This is the strongest argument for treating *meridionalis* as merely a race of the latter species. I have not done so, however, because *meridionalis* females are, on the average, smaller than both the southern and the northern races of *quadricolor*; *meridionalis* is sharply distinct in colour from the races of *quadricolor* which it almost overlaps in France and Denmark, though these southern and northern races, which have a discontinuous distribution, differ relatively very little from one another. The host of *Ps. meridionalis* is *Bombus soröensis*, F., race *proteus*, Gerst. (see discussion of hosts on p. 361), whereas the host of *Ps. quadricolor* is unknown, though if *soröensis* at all, cannot be the race *proteus*.

Psithyrus sylvestris, Lep.

Ps. quadricolor var. *sylvestris*, Lepeletier de St. Fargeau (1832), p. 377, and (1841), p. 428. *Apathus sylvestris*, Thomson (1872), p. 49; Sahlberg (1889), p. 172; Strand (1898), p. 84. *Ps. quadricolor* var. *silvester*, Friese and Dalla Torre (1894), p. 34. *Apathus barbutellus*, Smith (1876), p. 222 (in part). *Bombus quadricolor*, Gerstaecker (1869), p. 329 (probably), and (1872), p. 298. *Ps. quadricolor*, Schenck (1851), p. 76 (♂), and (1853), p. 266 (♂); Kriechbaumer (1854), p. 185 (vars. 3 and 4 of the ♀; 3–5 of the ♂); Kirchner (1857), p. 122 (♂); Schenck (1859), p. 165; H. Mueller (1881), p. 590; Schmiedeknecht (1882/4), p. 406; Saunders (1883), p. 267, and (1884), p. 229; Pérez (1884), p. 266 (in part); Handlirsch (1888), p. 247 (in part); Hoffer (1889), p. 149; Meunier (1889), p. 79; Dalla Torre (1896), p. 570; Saunders (1896), pp. 355 and 358; Ducke (1898), p. 141; Frey-Gessner (1900), pp. 72 and 76; Lie-Pettersen (1900), p. 17; Wegelin (1900), p. 132; Frionnet (1901), pp. 179–81, and p. 183 (in part); Friese (1902), p. 484; Aurivillius (1903), pp. 156–7; Sparre-Schneider (1906), p. 158 (in part); Schmiedeknecht (1907), pp. 141–2; Saunders (1909), p. 84; Franklin (1912), p. 476; Frey-Gessner (1912), pp. 75, 77 and 81; Alfken (1914), pp. 134 and 165; Ball (1914), pp. 107, 108; Strand (1915), p. 138; Bluethgen (1916), p. 40; Sparre-Schneider (1917), pp. 38–9 (in part); Jørgensen (1918), p. 119, and p. 122; Mocsary (1918), p. 102; Bluethgen (1919), p. 129; Forsius & Nordstroem (1921), p. 76; Jorgensen (1921), p. 254; Perkins (1921), p. 85; Bradley (1922), p. 141; Fahringer (1922), p. 209 (probably); Maidl (1922), p. 102 (probably), Bradley (1923), p. 17; Bluethgen (1924), p. 165; Stelfox (1924), p. 23; Wild (1924), p. 59; Bischoff (1925), p. 296; Strohm (1925), p. 209; Popov (1927), pp. 272–3. Vuyck, De Levende Natuur (1922), p. 120; *Apathus brasiliensis*,† Smith (1854), p. 385.

Lepeletier treats this species as a variety of what is in reality a distinct species, viz. *Ps. quadricolor*, Lep. I do not, therefore, transcribe the Latin diagnosis referring to both forms.

Original description :—(N.B. In the original, only differences from *quadricolor* are noted; for the description of that species see p. 347 of the present paper.) "Bord postérieur de l'écusson n'ayant qu'une partie (plus ou moins) de ses poils d'un gris jaunâtre. Troisième segment de l'abdomen entièrement blanc; le cinquième noir, avec les côtés blancs; le sixième roux, ainsi que l'anus. Le reste comme dans la première variété. Mâle. Sous-var. 1. Écusson entièrement noir. 2. Écusson et premier segment de l'abdomen entièrement noir. Hab. Les Pyrénées et les environs de Paris."

* Unless this was really a melanic *Ps. sylvestris*, Lep.

† I have examined the type of *A. brasiliensis*; the locality given (Pará) is doubtless an error.

Lepeletier's description fits the male of what is usually known as *Ps. quadricolor* and is not applicable in its entirety to any other species, except some specimens of *Ps. norvegicus*, Sp. Schn., which is not yet recorded from France.

Diagnostic characters. In the female the scape of the antennae is sparsely haired and very shining, in the male also relatively sparsely haired. The disc of the fifth tergite in the female has scattered punctures which become very dense at its apical margin. These punctures are fewer on the disc and less dense apically in the other species, in which, also, the sixth tergite is more shining and less punctured. In the male of *Ps. sylvestris* the sixth sternite has a strongly developed, bilobed, apical callosity. The black hairs of the fifth tergite distinguish the female from *Ps. quadricolor* and *meridionalis*. There are fewer pale hairs on the head and thorax and more on the abdomen than in *Ps. lissonurus*. In the male, there are nearly always black hairs (and never red ones) on the fifth tergite; for differences from *norvegicus*, see under that species.

Colour-variation. Female. The normal form is as follows:—Black; vertex sometimes with many yellow hairs, more often with few or none; a fairly broad yellow collar not continued below the anterior spiracle; 1 with many yellow hairs especially at its sides; 2 black; 3 black, apically narrowly white in its centre more than half white at its sides; 4 white; 5 black, hairs sometimes reddish tipped; hairs of legs black.

1. Size varies considerably, some specimens being very small.

2. 1 is often entirely black. When segment 1 is mainly yellow, the pale tuft on the vertex is often well developed and *vice versâ*.

3. The black may spread on 3 so that the white of that segment is divided into two lateral patches. Conversely, there may be a little white at the apex of 2. In the latter case 3 may be mainly white with only some black hairs intermixed on the disc basally, *e.g.* a female caught by Mr. A. E. Bradley at Roundhay near Leeds, 11 June, 1922. The pattern of this specimen is as follows:—Vertical pale tuft well developed; collar broad; 1 with numerous yellow hairs; 2 black with some pale hairs at its apex; 3 mainly white, some black hairs intermixed on its disc; 4 white; 5 black. This must probably be regarded as the female corresponding to the male I describe later as var. *albicans*. Two almost similar specimens come from Roundhay and Llanfairfechan, Carnarvon (coll. A. E. Bradley), one from Jette, Belgium, 6 May, 1915, in the collection of the Belgium National Mus., one from Aragnouet, France, in the Pérez coll., and one from Bellevue, France, in the de Gaulle coll., in the Paris Mus.

4. One female captured by J. Hardy at Llangollen, N. Wales, and in the collection of the Manchester Mus., is entirely black, var. **atricans,** n. var.

5. The corbicular hairs are occasionally more or less reddish; *e.g.* the female of the *albicans* type taken by Mr. A. E. Bradley at Llanfairfechan has these hairs entirely light reddish-yellow.

6. The single female I have seen from Asseja (Guv. St. Petersburg), Russia, kindly sent by Mr. Popov, has a much broader collar than is found in British specimens.

Male. The normal form is as follows:—Black; the tuft on the vertex usually black and yellow mixed, sometimes entirely one or the other colour; a fairly broad collar, not continued below the anterior spiracle; sometimes a few yellow hairs intermixed on the scutellum, rarely many, more often the scutellum appearing black to the naked eye; 1 black with some or many yellow hairs at its sides; 2 black; 3 white with a few black hairs intermixed on the disc basally;

4 white; 5 black with white or reddish hairs at its sides; 6–7 pale red, except that many black hairs are intermixed on the disc of 6 basally; many hairs on the hind tibiae reddish or reddish tipped.

1. 1 may be entirely yellow, or entirely black, all intermediates occurring.

2. White hairs may spread on to 5. Here they first appear as a narrow basal band, spreading over the segment till it appears white to the naked eye, though black hairs intermixed can usually be detected under the microscope. In such specimens there may, also, be little black on either 6 or 3, and there may be a little white at the apex of 2 in the centre. For forms in which 5 is entirely or mainly white I propose the name **albicans,** n. var. The type is a specimen from Glastonbury (Somerset) caught by E. Saunders in June, 1905, and in the collection of the British Mus. This is like the type-form, but the vertex is largely yellow; 1 is mainly yellow; 5 is entirely white. Other specimens: 4 Shotover, Oxon., 26 June, 1898, A. H. Hamm; common in Bagley Wood, Berks, June, 1927; one Rainow, Cheshire, F. Neave, in the collection of the Manchester Mus.; four from Tromsoe, 15 Aug., 1891, Sparre-Schneider, in the Tromsoe Mus. collection; and one Hertogenwald, Belgium, 18 to 25 June, 1913, in the Belgian National Mus.

3. The hairs of 6 may be entirely black; sometimes only the sides of 7 are red. These forms may have more black hairs intermixed on 3 and even some on the disc of 4 at its base. Of these specimens a few have the collar much reduced and sometimes only traceable at the sides. Varieties with the collar absent or only indicated at the sides may be called **atrithorax,** n. var. Such a specimen (in my collection) is one I captured at Bagley Wood, Berks, 16 June, 1926. This is like the type-form, but the vertical tuft is black, collar just indicated at the sides; 1–3 black, the latter segment posteriorly narrowly white in the centre, more than half white at the sides. Near Leeds Mr. A. E. Bradley has taken still darker specimens, *e.g.* black; collar faintly indicated; 1–3 black; 4 black, mixed with fuscous-white, especially at the sides. I have seen a specimen almost equally dark from Randøsund, Norway (in coll. Oslo Mus.).

Finally I have seen four specimens which probably correspond to the female already described as *atricans*. One taken by Mr. A. E. Bradley at Roundhay, near Leeds, 6 Aug., 1922, is black, the collar faintly indicated by a few greyish hairs on each side, and a few reddish hairs on 6 and 7. One captured by F. Neave at Rainow, Cheshire, June, 1920 (Manchester Mus.), is black with even fewer reddish hairs in the tail. Two caught in Bagley Wood, Berks, June, 1927, one by Mr. A. H. Hamm and one by myself, are black with a few paler hairs intermixed at the lateral apex of 3 and the sides of 4.

4. *Citrinus*, Schmiedk. (1882/4, p. 406). Franklin (1912, p. 476) has changed the name of *citrinus* to *confinis* on the grounds that Smith had previously described a *Psithyrus citrinus* (really a variety of *Ps. laboriosus*, F.). Franklin's change appears to me to be entirely unnecessary.

In these *citrinus*-forms the white of the tail is replaced by bright yellow. There are all intermediates from white to yellowish white, bright yellow to dirty yellow and on to blackish. The yellow of the head and thorax is often rather reduced. Variation of the types (1), (2) and (3) all occur in *citrinus*. Variation of type (2) leads up to the pattern of a male caught by Mr. A. E. Bradley at Roundhay, near Leeds, 17 July, 1921, which is like the type-form, with a large pale vertical tuft; 1 mostly yellow; 2 black, apex pale yellow; 3–7 light yellow. This I propose to call **bradleyi,** n. var. A male from Comrie, Perth, 5 July, 1900 (Royal Scottish Mus.), is intermediate between the previous

variety and ordinary *citrinus*, 5 being much mixed with yellow and the black of 3 and 6–7 being much reduced. I have seen three males with rather more yellow hairs than in this Scottish specimen, from Helsinge and Karislojo, Finland, sent by Dr. Forsius.

Variation of type (3) leads to a form, corresponding to *atrithorax*, which was caught by Mr. A. E. Bradley at Roundhay, near Leeds, 10 July, 1921. This is like the type-form but the vertical tuft is black; collar only faintly indicated; 1–3 black; 4 black, much mixed with fuscous-yellow, especially at its sides. For this form I propose the name **fuscocitrinus,** n. var. A somewhat darker specimen was caught in Bagley Wood, Berks, 15 June, 1927.

5. A single male from Outrosenvaera, Hühtamäki, Finland, 65° N., 19 July, 1894 (collected by Stenroos), kindly sent me by Dr. Forsius, is somewhat peculiar and will, perhaps, prove to belong to a special geographical race. This specimen has the following pattern: –Black; vertical tuft entirely yellow, as also are some of the hairs on the occipital margin on each side; a broad yellow collar, not continued below the anterior spiracle; a few yellow hairs mixed with those of the scutellum; 1 yellow; 2 black with a few white hairs at the apex on each side; 3 4 white; 5 with the sides and base white, black towards the apex on the disc; 6–7 light red; hairs of the legs mainly black, those of the hind femora, both above and below, mainly yellow. **Carelicus** n. var. (named after the province of Carelia pomorica occidentalis).

Range. I have examined 169 females and 465 males of this species, including specimens from Russia, Finland, Norway, Scotland, Ireland, England, Belgium, France, Germany, Austria and Switzerland. The northernmost examples came from Tromsoe and the most southern from Tarbes (Pyrenees). The species has, probably, a continuous distribution throughout Europe, and there is little indication of geographical variation. Possibly the form described as *carelicus* may prove to represent an arctic race. Through the kindness of M. A. Ball of the Belgian National Mus., I have been able to compare all the British species of *Psithyrus* with the corresponding Belgian forms, and I find in every case that the yellow hairs are relatively reduced in the British specimens. This tendency is also shown in *Ps. sylvestris*, though to a much smaller extent than in the other species. Thus of the 61 British females examined, 26 have the hairs of 1 entirely black and 35 have the sides of this segment yellow; while of the 72 Belgian females, only 18 have the hairs of 1 black, 54 having them more or less yellow. I think a similar tendency could be shown in the yellow hairs of the other parts of the female's body and of the male, but I have not yet discovered an effective method of measurement.

The variety *citrinus*, Schmiedk., appears to occur sporadically throughout the range of the species. In England, of 243 males 30 were of this variety; in Belgium 19 out of 144; in Germany 5 out of 43, and in Norway 3 out of 33; thus the proportion of variety to type-form was 1:7.1, 1:6.6, 1:7.6 and 1:10, respectively (the last-named ratio being derived from the examination of a rather small number of specimens). It is very curious that the frequency of the variety should be the same in such widely separated areas. One explanation would appear to be that there was a certain amount of interbreeding between the bee-populations of the countries mentioned.

Psithyrus lissonurus, Thomson.

Apathus lissonurus, Thomson (1872), p. 49; Strand (1898), p. 84. *Ps. lissonurus*, Schmiedeknecht (1882/4), p. 408 (in part; Kriechbaumer's specimens, which he refers here, are really *Ps. quadricolor*, Lep.). *Ps. quadricolor* var. *lissonurus*, Pérez (1884), p. 266; Frionnet (1901), pp.

179–81, and p. 183. *Ps. quadricolor* st. *lissonurus*, Dalla Torre (1896), p. 570. *Ps. lissonurus*, Hoffer (1888), p. 156; Sahlberg (1889), p. 172; Friese and Dalla Torre (1894), p. 34; Frey-Gessner (1900), pp. 72 and 76; Friese (1902), p. 484; Aurivillius (1903), p. 156–7; Sparre-Schneider (1906), p. 159; Schmiedeknecht (1907), pp. 141, 142; Frey-Gessner (1912), pp. 75, 77 and 81; Forsius and Nordström (1921), p. 76; Soot-Ryen (1925), p. 6; Popov (1927), pp. 272–3. *Ps. quadricolor*, Handlirsch (1888), p. 247 (vars. mentioned from Lappland, Raibl, Schluderbach and Stilfersjoch). *Ps. quadricolor* var. *lutescens*, Pérez (1890), p. 23. *Bombus autumnalis*, Zetterstedt (1838), p. 474 (male).

Original description :—"Niger, vertice medio, fascia antica lata, thoracis, scutello segmentoque 4 : 0 dorsali fere toto obscure sulphureis, ultimo nitido, glabro; mas segmentis dorsalibus 3 : 4 sordide sulphureis, 5 : 0 nigro, 6–7 rubris. A specie praecedente (*sylvestris*) femina labri fovea et lamina obsoletiore, segmenti 5 ultimo dorsali glabro; nitido, 5 : 0 obscure sulphureo, medio vix nigro, vertice et scutello flavis; mas tibiis posticis et tarsis omnibus fulvopilosis, segmentis dorsalibus 4 : 0 toto 3 : 0 saltim postice sordide sulphureis vel rufescentibus, forcipis squama oblonga, intus processum paullo majorem emittente, apice rotundato haud prominulo certe distinctus." Habitat: Lappland.

Diagnostic characters. Most like *Ps. sylvestris*, Lep., but the scape of the antennae is duller and more hairy; this is very marked in the alpine males. In the female the labrum is often less punctured than in the other species. In the male the squama is rather narrower and is little incurved. The apical callosity of the sixth sternite is often little developed. In both sexes there are normally fewer yellow hairs on the abdomen and more on the head and thorax than in the other species (but cf. race *alpium*). The yellow of the abdomen is ochreous, much less bright than in the *citrinus*-forms of *Ps. sylvestris*, Lep., with which the race *alpium* is easily confused.

Colour-variation. Female. Black; tuft of the vertex mostly composed of yellow hairs; a broad yellow collar not continued below the anterior spiracle; many yellow hairs on the scutellum, which is markedly pale to the naked eye; 1–3 black; 4 with the whole base very narrowly and the disc black, the sides yellowish-white; 5 black; tibial hairs black.

1. One female from Tromsoe, 10/vii/98 (in coll. Tromsoe Mus.), is like the type-form but the abdomen is entirely black. For this form I propose the name **atricolor**, n. var.

2. Some of the females from S. Norway (Oslo Mus.) have few or no yellow hairs on the scutellum. Four females from Finland (sent by Dr. Forsius) are similar to these S. Norwegian ones, but the yellow of the collar is paler and the average size appears to be larger. Possibly the typical form of the species is only found in the far north, and in more southern districts, as well as in the Alps, special races have been developed.

3. Frey-Gessner (1900, p. 72 and p. 76) describes the colour-pattern of *lissonurus* in Switzerland as follows:—Black; a pale tuft on the vertex; collar yellow; scutellar region yellow-brown; pale hairs of 3 and 4 in fresh specimens yellowish-white, those of 3 often interrupted or only continuous apically. The Swiss form differs, then, from the typical in having numerous pale hairs on 3. I have not been fortunate enough to examine a female from the Alps, but I have seen many males which I consider form a special race, which I propose to call *alpium*, n. race. Frey-Gessner's females correspond to these males in the more numerous pale hairs on the abdomen.

Male. Black; a large yellow vertical tuft; a broad yellow collar, not continued below the anterior spiracle; scutellum with numerous yellow hairs; 1 with yellow hairs intermixed laterally; 2 black; 3 black, dirty yellow at the

sides apically; 4 dirty yellow; 5 black; 6–7 red, disc of 6 more or less black; tibial hairs more or less red.

1. The black hairs of 3 may be reduced to a certain number intermixed on the disc, or, conversely, 3 may be almost entirely black. Sometimes the yellow of 3 and 4 is almost brown.

2. 1 may be entirely yellow or black, intermediate variations being the most numerous.

3. The tibial hairs are occasionally black, though more often distinctly reddish.

4. Frey-Gessner (1900, p. 73 and p. 76) describes the males of *lissonurus* in Switzerland as having 3 and 4 dirty sulphur yellow. I have examined 12 males from various localities in the Alps and I find, with one exception, they always have at least some pale hairs on 2; perhaps these hairs have been overlooked by Frey-Gessner. These alpine forms have the following pattern :— Black; a large yellow tuft on the vertex; a broad yellow collar, usually not continued below the anterior spiracle, never very far; many yellow hairs on the scutellum; many yellow hairs on 1 especially laterally; 2 yellow except for the sides basally; 3–4 yellow; 5 black, sides yellow; 6–7 light red, sometimes with black hairs intermixed on the base of 6; tibial hairs more or less reddish.

The exception is a male caught at La Bérarde, Isère, France (28 Aug., 1923), which resembles the Norwegian males except that the scutellum and 1 are black and that there is little red on 6–7.

In some specimens even the black of the sides of 2 is much yellow mixed; in others only the apical part of 2 has any yellow hairs and the disc of 3 and 4 is black mixed. The yellow of the abdomen is paler than in *lissonurus* and more ochreous than in the *citrinus* forms of *sylvestris*. These alpine males form the race **alpium,** n. race. As the types I choose three males from Bérisal, Switzerland (1 July, 1895), in the Morice coll., in the Hope department, Oxford Mus.

5. Pérez (1890, p. 23) mentions a variety of *Ps. quadricolor*, Lep., from the Pyrenees, which he calls *lutescens*, Pérez; his description is merely " 1–4 flavis." In the Pérez coll. in the Paris Mus. there are three males of which one is certainly the type of this variety. These males are a form of *Ps. lissonurus*, Thoms., in which the collar extends further down the pleura, of which, in two specimens, the greater part is yellow, and segments 1–4 are yellow except for a few black hairs at the sides of 2. Another Pyrenaean male (Pandelle coll.) resembles the race *alpium*, but the collar is continued much more distinctly below the anterior spiracle. Probably further material would show that there was a special Pyrenaean race of *lissonurus* characterised by the great extension of the yellow hairs. A male sent by Dr. Forsius from Ivalo in Finland resembles Pérez's variety in having 1–4 yellow, save for a few black hairs on the base of the disc of 2.

6. Males resembling *alpium* occur sporadically in Norway, though as yet no corresponding females have been seen. These Norwegian males of which I have seen seven from various parts of Norway (6 in the Tromsoe Mus., 1 in the British Mus.) appear to be rather darker than the specimens caught in the Alps, the yellow being less extensive and transitions to typical *lissonurus* occurring.

Range. Ps. lissonurus lissonurus, Thoms. I have seen 13 females and 35 males from Norway and 5 females and 5 males from Finland. Also occurs in Sweden and Lappland. *Ps. lissonurus alpium* : France (Pyrenees and Isère);

Switzerland (Simplon and many localities given by Frey-Gessner); Austria (Mäder); Italy (Seiser Alpe). The *alpium*-like males found in Norway may be called var. *alpium*.

Psithyrus norvegicus, Sparre-Schneider.

Psithyrus norvegicus, Sparre-Schneider (1917), pp. 40–45; Popov (1927), p. 268.

Original description :—(Female only), pp. 40–1. "Es ist ein ansehnliches Tier, etwa so gross wie *Ps. vestalis*, mit dem es oberflächlich eine verblüffende Aehnlichkeit zeigt. Schwarz, Stirn und Halskragen breit gelb, im Schildchen hellere Haare undeutlich eingemischt, das erste Abdomenssegment seitlich ebenfalls mit zerstreuten gelben Haaren, besonders bei dem einen Stücke stärker markiert, die Segmente 3 und 4 bei 2 Stücken gelblich weiss behaart, bei dem dritten ist die Behaarung mehr rötlich weiss, das 5te Segment seitlich mit rötlichen und einigen schwarzen Haaren dünn besetzt, dies Segment also ungefähr wie bei *Ps. quadricolor* gefärbt. Die plastichen Merkmale sind sehr auffallend. Der hintere Metatarsus ist schmal, etwas wie bei *quadricolor* der mit der *norvegicus* am nächsten verwandt ist, es ist aber der Endring, der die grössten Eigentümlichkeiten zeigt. Der Hinterleib ist überaus stark hakenförmig eingekrümmt, so dass ich die Unterseite des Analringes, ohne die kostbaren Tiere zu verletzen, nicht ganz genau zu untersuchen vermag, soviel kann ich jedoch sehen, dass die Analspitze auch an der Unterseite eine eigentümliche Bildung zeigt. Die Oberseite ist wie bei den meisten anderen Arten glatt und glänzend, stark zugespitzt, und fast in der ganzen Länge mit einem recht starken Kiele versehen wie bei keiner der anderen mir vorliegenden Species. Die Spitze ist seitlich dicht mit roten Filshaaren bekleidet." Three females, Braaten, near Oslo, 1, v/16, 2, vi/17.

This is a distinct species which has been confused with *Ps. sylvestris*, Lep. Possibly the female mentioned by Sparre-Schneider, in which the hairs of 3 were more reddish, was really a *Ps. quadricolor*, Lep.

Diagnostic characters. In the female the size is large, the scape dull, the malar space is long, and the clypeus strongly punctured; the labral lamella is relatively large; the last tergite is often almost keeled. In the male the scape is densely hairy, the third antennal joint is distinctly shorter than the fifth, and the volsella of the genitalia is densely hairy on the inside (genitalia, fig. 6). Much resembles *Ps. sylvestris*, Lep., in colour, but in the female the vertex nearly always has a marked pale tuft, the collar is broader and paler; the yellow of 1 confined to the sides where it occupies only the apical half of the segment. In the male there is often less red on 6–7.

Colour-variation. Female. The normal form is :—Black; many pale hairs on the vertex; a broad pale yellow collar not continued below the anterior spiracle; 1 black with a patch of yellow hairs apically at each side; 2 black; 3 black on the disc, almost entirely white at the sides; 4 white; 5 black; tibial hairs black.

1. 1 may be entirely black.

2. The single female I have seen from Russia has a rather shorter malar space than Norwegian or German specimens.

Male. Black; many yellow hairs on the vertex; a broad yellow collar, not continued below the anterior spiracle; 1 black, yellow laterally; 2 black with pale hairs on the disc apically; 3 white with a few black hairs intermixed on the disc laterally; 7 red; hairs of legs black.

1. The pale hairs of 3 and 4 may be yellow: var. *pseudocitrinus*, Popov (1927, p. 269), described from a single male captured in Transbaicalia. I have seen one male from Dresden (in my collection) and one male from Eygebirge, in the British Mus.

2. If in the variety *pseudocitrinus* the scutellum is yellow and the black band between the wings is much yellow mixed, the specimen becomes var. *transbaicalicus*, Popov (1927, p. 269), described from one male taken in Transbaicalia.

*Range.** Owing to our present small knowledge of the distribution, I give full details. Besides the specimens mentioned under *pseudocitrinus* I have seen the following :—*Females*. Russia, one, St. Petersburg, 30/v/24 (sent by Mr. Popov). Norway, three, Slemdal, v/10, and two vi/17; one, Nordmo, Malselven, vii/17; one, Stromome (all in the Tromsoe Mus.; these are the material from which Sparre-Schneider described the species, though a type specimen was not indicated); one, Valders (Oslo Mus.); one, "Norway" (in the British Mus.). Germany, two, Dresden (in my coll.). *Males*. Russia, one, Chotilovo, Gub. Novgorod, 7/vii/26 (sent by Mr. Popov). Norway, one, Sogne Fjord, Balholmen, 18/vii/26; one, Faenlands Fjord, Mundal, 17/vii/26 (in the Hope department, Oxford Mus.); one, Slemdal, 4/viii/10; one, Bjerkeng, 14/vii/95; one, Tromsoe (in the Tromsoe Mus.). Belgium, one, Losheimergraben, 8 to 11/viii/21 (in the Belgian National Mus.). Germany, one, Braunschweig; one, Berlin district (in my coll.). Switzerland, one, Via Mala, Grisons, 15/vii/25 (in my coll.). Popov (1927, pp. 269–70) gives a number of other Russian records of this species, and also records one male from Austria.

Psithyrus skorikovi, Popov.

Ps. skorikovi, Popov (1927, p. 267, and fig. 1).

Original description :—"Female. Head distinctly longer than wide at the eyes (H–L = 0·5 mm.); malar space as long as its width at the articulation with the mandible (h = l = 1 mm.). Clypeus moderately convex, covered with unequal, coarse and strong points, most sparse towards the labrum. Labrum large, more than one-half longer than wide, coarsely punctured. Malar space very closely and rather hardly punctured, points sparse, its apex punctured more sparsely and coarsely than the base. Hind metatarsi three times as long as their largest width, prolongated into a sharp and rather narrow tooth, its posterior margin distinctly arcuate. Abdomen shining, moderately punctured, the points fine and not very close. Sixth abdominal segment rather pointed, drowning and very strongly bent under the abdomen. Lateral margins and apex of the sixth tergite (epipygium) minutely punctured and provided with an hardly visible, slight median carina on apical portion of the tergite. Sixth sternite (hypopygium) with low and gradually elevated lateral carinae (fig. 1), these latter being less convex than those in *Ps. norvegicus* and *Ps. lissonurus* and forming a more sharp-pointed figure than in both named species. Portion of the last sternite lying between the carinae, covered with coarse unequal and sparse punctures, still more sparse in the middle of the basal area.

"Black; prothorax, propleurae and the apical, largest part of scutellum, tergite I, pleurae and basal part of tergite II, pleurae of tergite III, and, probably tergite IV (specimen is rather old) yellow; tergite VI covered with brownish-ferruginous pubescence. Hairs of the body rather short and coarse. China, Gan-su, northern slopes of the Sinin Mountains, before 1.vii.1910, G. E. and M. E. Grum-Grzhimajlo. Type, a female, in the collection of the Zoological Museum of the Russian Academy of Sciences (from the collection of Mr. Semenov-Tian-Shanskij.)"

Closely allied to *Ps. norvegicus*, Sparre-Schneider.

* L. Vuyck in a paper in *De Levende Natuur*, 26 (1922), describes on p. 120 the Dutch form of what he terms *Psithyrus quadricolor*, Lep. He describes a keel on the sixth abdominal tergite of the female ; perhaps *Ps. norvegicus* also occurs in Holland ?

Female. Diagnostic characters. A medium-sized species, smaller than *Ps. norvegicus*. Lamella of labrum rather strongly produced, tubercles with many punctures. Clypeus strongly and densely punctured, except for a quite small central anterior space. Malar space long, as in *Ps. norvegicus*, but more strongly punctured than in any other species of the group. Hairs on the scape of the antennae longer and denser than in any of the other species. Long hairs of the first abdominal sternite not approaching the margin so closely as in *Ps. sylvestris*; very little decumbent pubescence between these long hairs and the margin of the segment. Fifth tergite strongly and closely punctured along the posterior margin, hardly at all on its disc. Last tergite with a long keel. Hairs of the abdomen rather denser than in the other species.

Colour. Black; vertical tuft yellow and black mixed; a very broad anterior thoracic collar, still broader laterally, scarcely produced below the anterior spiracle; scutellum and postscutellum, except for the disc of the former, with yellow hairs, very conspicuous to the naked eye; 1 yellow; 2 black with two lateral, yellow, apical patches, becoming still broader at the extreme sides; 3 yellow, disc black; 4 black with lateral yellow patches; 5 black; short hairs of 6 pale; hairs of legs black; wings only a little infuscate.

Three females in the British Mus., two from Gyangtse, Tibet, June, 1904, H. J. Walton, from the Tibet expedition, and one female, Gulmarg, Kashmir, summer 1913, Lt.-Col. F. W. Thomson. Another female from Khamba Jong, Sikkim, 15 to 30 July, 1903, taken by the Tibet expedition is slightly different. The keel of the sixth tergite is less marked. The vertical tuft is black; there are no pale hairs at the apex of 2 and the base of 3 is narrowly black-mixed right across the segment. Two further females in the British Museum (Phari, Tibet, 14,000 ft., 21 July, 1924, Major R. W. G. Hingston, 2nd Mt. Everest Expedition) differ in having the whole of 3 and 4 yellow = **mesoxanthus,** n. var.

In all six females the yellow is ochreous, rather paler than in *Ps. lissonurus* race *alpium*. I think there is no doubt that these females are the species Popov has described.

Psithyrus fernaldae, Franklin.

Ps. fernaldae, Franklin (1911), p. 164; (1912), p. 473. *Ps. tricolor* Franklin (1911), p. 167 (male); (1912), p. 476 (male).

I give a few notes on this American species to complete my account of the group. I have not been able to examine a female, but I give a description of the colour drawn from Franklin's description (1912).

Black; vertical tuft yellow; thorax above yellow with or without a more or less indicated, black interalar band; upper half of the pleura yellow, sometimes the lower half also; sides of 1 yellow, 2 black, usually the sides of 3 at its apex yellow, 4 yellow, 5 light red.

I have examined some males in the collection in the British Museum. Structurally, as might be expected from the colour-pattern of the female, they are closely allied to *Ps. quadricolor*, Lep. They differ, however, in the rather shorter and thicker antennae, in which the fifth joint is distinctly shorter than the sixth, instead of equal to it. The scape is densely hairy. The sixth sternite has no apical callosity, and the genitalia appear exactly like those of *Ps. quadricolor*, Lep. For the colour-pattern I follow Franklin (1912), who examined much more material than I was able to. Black; sometimes a few yellow hairs above the antennae, besides the yellow vertical tuft; thorax

yellow, usually with a poorly defined black interalar band or a black discal spot; pleura usually yellow, but sometimes the posterior and lower halves black; 1 yellow or mostly so; 2 yellow, or yellow on the disc only; 3 yellow, or yellow with a black disc, or, rarely, all black; 4 yellow; 5 black, sometimes a little yellow or ferruginous mixed; 6 ferruginous, sometimes with a few black hairs at its base; 7 ferruginous; venter and legs with mainly yellow hairs.

It is interesting that the fifth tergite should have black hairs in a species in which they are red in the female.

The Hosts of the *quadricolor* Group of *Psithyrus*.

The actual records of the hosts of the various species are rather meagre, many authors merely quoting the observations of earlier workers.

It is certain from the observations of Hoffer (1888, p. 73) and Smith (1876, p. 220) that *Ps. sylvestris*, Lep. (*quadricolor* of the former, *barbutellus* of the latter author), is a parasite of *Bombus pratorum*, L. Smith also found this species of *Psithyrus* in the nest of the allied *B. jonellus*, K. Through the kindness of Dr. R. C. L. Perkins I have been able to examine one of the males of *Ps. sylvestris* bred by Smith from a nest of *jonellus* in Scotland. Stelfox (1924, p. 23) also records that in Ireland (Dublin district) *Ps. sylvestris* is only found in the hills where *jonellus* occurs; Dr. Perkins suspects that *jonellus* is the host on some parts of Dartmoor.

Ps. meridionalis, n. sp., is a parasite of *B. soröensis*, F., race *proteus*, Gerst. (see Hoffer, *loc. cit.* p. 76; Friese, 1923*b*, p. 388). This race of *soröensis* occurs in Germany, Austria, Switzerland and the Alps generally. In the greater part of the range of this race various varieties of it are the sole representatives of *soröensis*; if white-tailed, typical forms occur at all, they are rare and usually only found in the males. In the north of Germany, where *soröensis soröensis*, F., and *s. proteus*, Gerst., meet, the races overlap considerably and interbreed (this is probably also the case in the Western Alps), but in most of the range of the species one or other of the races alone is found. *Ps. meridionalis* appears to occur only within the range of *B. s. proteus*, though it is not found everywhere its host occurs. Records of "*Ps. globosus*" from areas in which white-tailed *soröensis* is alone found, *e.g.* Scandinavia and S.W. France, always refer to races of *Ps. quadricolor*, Lep.

Sparre-Schneider (1906, p. 159) has suggested that *Ps. lissonurus*, Thoms., is a parasite of *Bombus kirbyellus*, Curt. I should say from the affinities of the latter bee that this was extremely improbable. Friese's suggestion (1923*b*, p. 388) that *B. lapponicus*, F., is the host is much more likely to be correct. Here again, however, the parasite is not found everywhere with its host (*e.g.* in England, where the *Bombus* is locally abundant, the parasite does not occur). The hosts of *Ps. norvegicus*, Sparre-Schneider, and of *Ps. quadricolor*, Lep., are at present unknown. The former species may be a parasite of *Bombus hypnorum*, F., which, if true, would account for the rarity of the parasite. The ranges of the two species coincide, and I have some evidence that they occur in the same localities. Dalla Torre (1896, p. 570) records *B. hypnorum*, F., as a host of his composite species *Ps. quadricolor*.

In the Himalayas, the specimens of *Ps. skorikovi*, Popov, I have recorded occurred where by far the commonest representatives of the subgenus *Pratobombus* were forms allied to *B. hypnorum*, F. (viz. *B. atrocinctus*, Sm., *B. terminalis*, Sm., and a new species). This suggests that *Ps. skorikovi* is a parasite

of these *hypnorum*-like forms, and, consequently, that *Ps. norvegicus*, which is closely allied to *Ps. skorikovi*, is a parasite of *B. hypnorum*.

With regard to *Ps. quadricolor*, Lep., Pérez (1884, p. 268) notes that he saw a female creep into the nest of *B. ruderarius*, Muell. (*derhamellus*, K.). This was doubtless merely a preliminary exploration: the bee stayed in the nest for ten minutes only. Hoffer (*loc. cit.* p. 73) similarly once found *Ps. sylvestris* in the nest of *B. agrorum*, F. *Psithyri* are well known to spend the night in nests of bees which they do not parasitise. It is probable that *Ps. quadricolor* parasitises a member of the subgenus *Pratobombus*, perhaps *B. pratorum*, L., itself, though it would be somewhat remarkable that that bee should have two closely allied parasites whose ranges overlap so considerably.

Systematic Summary.

Ps. quadricolor, Lep. (not *quadricolor* of most authors; = *globosus*, Eversm.; = *suaveolens*, Wahlbg.).
  Ps. q. quadricolor, Lep. Pyrenees.
  Ps. q. arvernicus, n. Auvergne and (?) Western Alps.
  Ps. q. globosus, Eversm. (*suaveolens*, Wahlbg., *intercalarius*, Muell.). Russia, Scandinavia, Finland, Esthonia and Denmark.
Ps. meridionalis, n. (*globosus*, auct. pars: nec *globosus*, Eversm.). Central Europe.
Ps. sylvestris, Lep. (*quadricolor* of most authors) (= *Apathus brasiliensis*, Smith). N. and C. Europe.
  var. *albicans*, n. England, Belgium and Norway.
    atrithorax, n. England and Norway.
    citrinus, Schmdk. (= *confinis*, Franklin). Occurs everywhere with the type but not common.
    bradleyi, n. England.
    fuscocitrinus, n. England.
    atricans, n. England.
    carelicus, n. Carelia, Finland.
Ps. lissonurus, Thoms. Scandinavia, Finland, Alps and Pyrenees.
  Ps. l. lissonurus, Thoms. Scandinavia and Finland.
    var. *atricolor*, n. Norway.
      alpium, n. Norway.
  Ps. l. alpium, n. Alps and Pyrenees.
    var. *lutescens*, Pérez. Pyrenees and Finland.
Ps. norvegicus, Sparre-Schneider. Russia, Norway, Belgium, Germany, Austria and Switzerland.
    var. *pseudocitrinus*, Popov. Germany and Transbaicalia.
      transbaicalicus, Popov. Transbaicalia.
Ps. skorikovi, Popov. China, Tibet, Kashmir.
    var. *mesoxanthus*, n. Tibet.
Ps. fernaldae, Frankl. (= *tricolor*, Frankl.). N. America.

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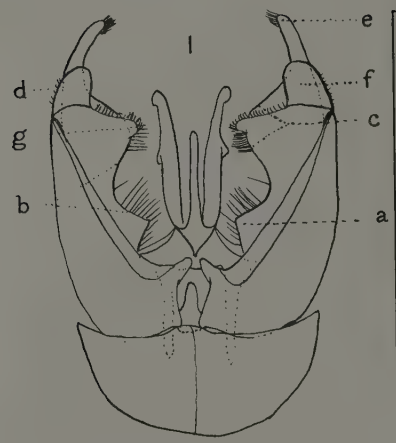

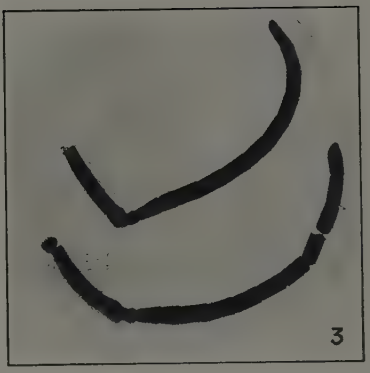

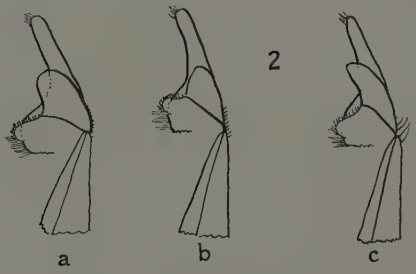

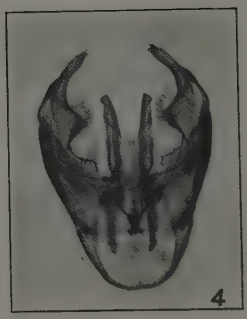

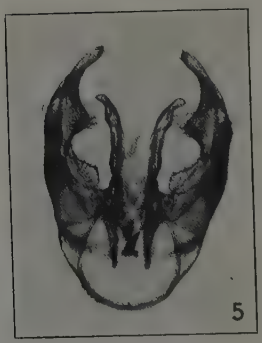

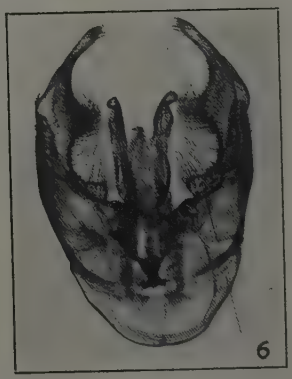

Vaus & Crampton, Lhd.

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Explanation of Plate XI.

Fig. 1. The genitalia of a male of the *Psithyrus quadricolor* group, in dorsal view showing the names of parts mentioned in the specific descriptions. (*a*) Basal lobe of the volsella. (*b*) Emargination of the volsella. (*c*) Median lobe of the volsella. (*d*) Tips of the hairs on the external surface of the volsella. (*e*) Apical tuft of the volsella. (*f*) Squama. (*g*) Internal process of the squama.

2. The apex of the volsella and the squama of (*a*) *Ps. sylvestris*, Lep., (*b*) *Ps. lissonurus*, Thoms., and (*c*) *Ps. quadricolor*, Lep., showing the specific differences in the shape of the squama. The exact shape varies with the aspect.

3. Antennae of the males of *Ps. sylvestris*, Lep., above and of *Ps. meridionalis*, n. sp., below, showing the hairs on the scape.

4. Genitalia of *Ps. sylvestris*, Lep. (× 16).

5. Genitalia of *Ps. meridionalis*, n. sp. (× 16). N.B.—The long external hairs of the volsella are not well shown, though visible on the left hand side.

6. Genitalia of *Ps. norvegicus*, Sp. Schn. (× 18).

THE VARIABILITY OF SPECIES IN THE LEPIDOPTERA, WITH REFERENCE TO ABUNDANCE AND SEX

By R. A. Fisher, Sc.D. (Rothamsted),
and E. B. Ford, M.A., B.Sc. (Department of Zoology and Comparative Anatomy, Oxford).

With an Appendix " On the Male and Female forms of the African Pterothysanid moth *Hibrildes norax*, Druce," by Edward B. Poulton, M.A., D.Sc., F.R.S., Hope Professor of Zoology in the University of Oxford, Fellow of Jesus College, Oxford.

[Read June 6th, 1928.]

Plate XII.

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(1). Introduction. [E. B. F.]

The present paper contains the results of recent work which the writers have carried out independently. They have, on the one hand, studied the variation to be expected theoretically in a population exhibiting Mendelian inheritance under the influence of selection, and, on the other, investigated the variability of certain Lepidoptera, chiefly common British moths. The conclusions at which they have arrived showed a somewhat striking agreement, and have already been published as a preliminary note (Fisher and Ford, 1926). It is now proposed to discuss them in greater detail and to publish the data.

Prof. E. B. Poulton, F.R.S., has given us much valuable help, and we have to thank him for placing the resources of the Hope Department, University of Oxford, at our disposal, also for authorising a grant in aid of these researches, from the Oxford University Fund for promoting the Study of Organic and Social Evolution. We are further indebted to him for writing the Appendix to this paper. One of us (E. B. F.) is indebted to the Department of Scientific and Industrial Research for a grant during the time that this and other work was in progress.

(2). The Problems Investigated. [E. B. F.]

One of the more important features of variation in the Lepidoptera is the remarkable unisexual polymorphism so frequent in that group. This has received most attention in the Rhopalocera owing to its connection with mimicry, but it also occurs among the Heterocera. Such polymorphism is by no means equally distributed between the sexes, for it is certainly more frequent in the female than in the male. Indeed we are unable to find a single instance of unisexual polymorphism of the male among mimetic butterflies, while in the female it is a frequent phenomenon in all parts of the tropics. Among the non-mimetic species the balance is again greatly in favour of the female, but not to the same extent; we shall return to this point in Section 6.

The importance of female mimicry has been emphasised by a number of workers; see, for example, the classical papers of Bates (1862), Wallace (1865), Trimen (1869), and Poulton (1916). Reference should be made to the latter paper for a discussion of the general bearings of the problem. Prof. Poulton suggests that it is an expression of a general tendency towards a greater female variability among butterflies as a whole, and points out that this conclusion is supported by certain differences in pattern which commonly exist between the sexes. In male butterflies the passage from one colour to another generally takes place suddenly, scales of one colour being replaced by those of another. In the case of females the change is gradual; an area in which the differently coloured scales are mixed in varying proportions occurs where two patches of colour join. In males the edges of the patterns thus tend to be hard (eulegnic) as compared with females, in which they are soft (dyslegnic). This would seem to indicate a generally greater instability of pattern in the latter sex, and is noticeable in the patterns of mimics as compared with models. Prof. Poulton says, "Dyslegnic patterns are not only common in mimics as compared with models, but are also common in females as compared with males. Thus the mimetic female forms of *Papilio dardanus* [Brown] bear in this respect the same relation to their Danaine models that they bear to their own male, and the female of the non-mimetic ancestor *P. meriones* [Feld.] in Madagascar is also far less eulegnic than its male."

The present work was originally designed to test by measurements of colour whether or not this marked excess of unisexual polymorphism in the female can be correlated with a relatively greater female variability in the group as a whole. In addition it was found that the data accumulated for this purpose supported certain theoretical conclusions on the relative variability of abundant and rare species; see Section 5.

(3). Methods and Material. [E. B. F.]

For the above purpose it was considered advisable to estimate the variation of the character chiefly concerned in unisexual polymorphism, *i.e.* wing-colour, in forms not known to exhibit this phenomenon. In this way any differential variability of the sexes might be detected. It is further desirable to study non-mimetic species, as there is strong ground for supposing that female variability may have a special selective value in mimetic forms (see Section 6). Accordingly a number of British moths, chiefly belonging to the Noctuidae, were chosen as suitable material.

The method employed was to match the ground-colour of the fore-wings against a colour chart ranging, for example, from white to black, and divided into twelve stages, which were made as nearly as possible equivalent. This was done by adding, between each stage, a given quantity of black paint

(in drops) to a fixed amount of white paint, calculated so that the last stage is not distinguishable from pure black. The first stage, numbered 1, being left white and the last, 12, being black.

The writers are aware of the disadvantages and unavoidable inaccuracies of any direct method of matching colours (particularly when it is necessary to arrive at an average value for a varied field). These difficulties have been clearly stated by Sumner (1927), and some modification of the Ives Tint Photometer recommended by him might possibly be applicable in this case. It is hoped that some worker may be sufficiently interested to experiment in this direction in the future. At the same time it must be remembered that no method which might in any way damage the specimens is admissible in examining large quantities of museum material. We have, however, taken the greatest care to standardise the methods used in the present work, and we are satisfied that they are within the limits of accuracy required to demonstrate our results, as the arbitrary characteristics of the colour scale have largely been eliminated by the mathematical treatment (Section 4, (1)).

All matching was done as far as possible in a uniform light, and tests were made to estimate the accuracy attained. It was found that only rarely were individuals placed in different groups upon a second independent examination. The entire data giving the original grouping, together with the results of examining certain species a second time for tests of accuracy, have been deposited in the Natural History Museum, South Kensington, in case they should be of use to any worker in the future and to avoid the high cost of excessive tabulation in the present paper.

It was not possible to compare all ground-colours with the same chart. Thus a number of different charts, ranging between different colours, were employed. In this way 54 species, giving a total of 7605 specimens, were studied. It was, however, found impossible to compare in any satisfactory way the results of matching against different charts. For this reason only those species matched against a single chart are considered in the present paper. This is the one with which the largest number had been compared. It was made in the way described above, but in two parts. Stages 2–7 being made by regular combinations of white with the shade of dark brown marked Vandyke Brown in Ridgway's Colour Chart (Ridgway, 1912), 8–12 being similar combinations of this colour with black. Treated in this way it was found that this particular shade gave a graded series from white to black well within the error of matching, and bringing in the necessary brown tint. This restriction reduces the number of species to 35, and the number of specimens to 5227; these are tabulated in Sections 4 and 9.

Care was exercised in regard to the insects studied. It was, of course, only possible to use species which vary to a measurable extent, and which could be obtained in some numbers. In double (or more) brooded species only those from the same brood were utilised. Further, in all cases where local variation was seen to exist, determinations were made only from specimens caught in the same locality. These restrictions reduced the available material very considerably.

Collections of Lepidoptera often give an exaggerated impression of the variability of any species, owing to the collectors tending to keep the extremes more frequently than the typical forms. This tendency will be at its minimum when the intention is to obtain large samples of the species, and it is from such collections that the present material is principally drawn. It seems improbable that it will introduce any error in the comparison of the variability either between the sexes or between species of varying abundance.

(4). Statistical Examination of the Data. [R. A. F.]

Taking the actual grades used in classification as empirical units of colour density, the mean and standard deviation of each sex were obtained by direct calculation (see Section 9). Shepherd's adjustment was not used, since this would not allow for the grading errors mentioned above. On comparing the sexes it is at once apparent that the female is generally both darker, and, so far as the standard deviation may be accepted, more variable than the male. Of the 35 species only one shows a male both lighter and less variable than the female, in both respects the difference being insignificant, so that a second sample might well reverse the difference. In three other cases the male, though less variable, is the darker, to an insignificant extent; in three more the male though lighter is more variable, and of these one, *Feltia clerica*, Butl., must be judged significantly more variable in the male. The remaining 28 species are both darker and more variable in the female.

In addition to the sex-comparison the species were classified in broad categories according to the two characteristics of Abundance and Range. Such a classification must necessarily be very imperfect. Thus 10 species could be placed in the most abundant group under the designations " abundant " or " very common," 12 more can be counted as " common," while the remaining 13 fall under such designations as " rather common," " common locally," " rather local," " local " and " rare." In respect of range the two most wide-spread fall into the class comprising " cosmopolitan," " holarctic " and " old world " distributions; 18 may be classed as " palaearctic," though, of course, their range is often less than the whole of this region; 13 may be classed as " European " in the same broad sense, while the remaining two are confined to

TABLE I.

Classification of Species by Abundance and Range.

	A. Abundant.	B. Common.	C. Less than common.
1. Cosmopolitan, etc.		*Hydroecia nictitans*, Bork.	*Agrotis saucia*, Hb.
2. Palaearctic	*Agrotis segetum*, Schiff. *Apamea secalis*, L. *Orrhodia vaccinii*, L. *Triphaena pronuba*, L. *Taeniocampa gothica*, L. *Taeniocampa incerta*, Hufn. *Xylophasia monoglypha*, Hufn.	*Agrotis corticea*, Hb. *Agrotis tritici*, L. *Bombycia viminalis*, Fb. *Dianthoecia carpophaga*, Bork. *Mamestra dentina*, Esp. *Mamestra pisi*, L. *Selenia bilunaria*, Esp.	*Agrotis puta*, Hb. *Eumichtis adusta*, Esp. *Miana bicoloria*, Vill. *Noctua dahlii*, Hb.
3. European	*Miana strigilis*, View. *Noctua xanthographa*, Fb. *Taeniocampa stabilis*, View.	*Amathes lychnidis*, Schiff. *Luperina testacea*, Hb. *Noctua rubi*, View.	*Agrotis agathina*, Dup. *Agrotis cinerea*, Hb. *Agrotis cursoria*, Bork. *Agrotis vestigialis*, Hufn. *Omphaloscelis lunosa*, Haw. *Selidosema ericetaria*, Vill. *Taeniocampa munda*, Esp.
4. Insular		*Feltia clerica*, Butl.	*Hydroecia crinanensis*, Burrows.

Great Britain and to the Falkland Islands respectively. The classification actually adopted is given in full in Table 1.

An examination of the average values of coloration in each class of the table, as set out below :—

TABLE 2.

Males.					Females.				
	A.	B.	C.	Mean.		A.	B.	C.	Mean.
1	—	5·42	6·89	6·16	1	—	6·15	7·28	6·72
2	5·93	4·52	4·80	5·13	2	7·35	5·66	6·98	6·61
3	5·83	6·12	4·86	5·50	3	7·04	6·76	6·27	6·09
4	—	7·42	5·33	6·38	4	—	9·48	5·66	7·57
Mean	5·90	5·24	5·03	5·35	Mean	7·26	6·29	6·51	6·65

shows that while there is no appreciable association between Range and pigmentation, Abundance is apparently so associated, for the abundant species are on the average distinctly darker than the remaining species. The averages of the standard deviations may be tabulated in the same way :—

TABLE 3.

Males.					Females.				
	A.	B.	C.	Mean.		A.	B.	C.	Mean.
1	—	1·051	1·955	1·503	1	—	1·237	2·159	1·698
2	1·594	0·908	1·146	1·228	2	1·887	1·414	1·376	1·584
3	1·509	1·257	0·833	1·009	3	1·758	1·629	1·346	1·399
4	—	1·867	0·952	1·410	4	—	1·460	0·912	1·186
Mean	1·568	1·087	1·025	1·201	Mean	1·848	1·457	1·385	1·542

Setting aside results obtained from only a single species, it is clear that in both sexes the variability, as measured so far, is greater in the more abundant species, and also to some extent in those with larger ranges. In spite of the very rough and provisional character of both classifications it is evident that it has not been sufficiently imperfect wholly to obscure the association of variability with abundance. With range the case is different; the apparent association might be due wholly to chance in the choice of the species examined; on the other hand, any real association of variability with range will certainly have been much obscured by the broad classification which it is necessary to use.

(4. 1.) Elimination of the Arbitrary Characteristics of the Colour Scale. [R. A. F.]

The comparisons of variability made so far are open to a most serious objection, for the comparisons we wish to make, between male and female, or between more and less abundant species, have in fact to be made between groups of insects with a different average depth of pigmentation; in each case the group apparently the more variable is certainly the darker. Consequently, we must consider the possibility that the apparent differences in variability are in whole or in part fictitious, owing to the grades at the darker end of the scale not having the same intrinsic value as those at the lighter end. The

difficulty is a fundamental one, since we have no criterion as to what would constitute intrinsically equal grades. It may indeed be supposed that for each species there exists a natural pigmentation scale such that equal genetic changes produce on the average equal effects in different parts of the scale; and we have no reason to assume that this scale will not be substantially the same for the different species. However, we have no means of calibrating the scale of grades actually used with such a natural scale of pigmentation; consequently, the only numerical conclusions which can be drawn from the data with certain validity must be such as to be independent of the relative values of the successive grades of our colour scale.

This it is possible, in some measure, to do, by taking account of the association between depth of pigment and variability within groups of species. For this purpose the classification by range may be ignored. For each of the three abundance classes, the values of the mean and of the standard deviation are diminished by the average values for the class, giving the deviations from the average; the sums of the squares of these deviations are then calculated for the species means, and the sums of the products for the mean and S.D. of each species. Any general tendency, whether due to the arbitrary characteristics of our colour scale, or not, for the darker species to appear the more variable, will be expressed by the ratio of the sum of the products to the sum of the squares. This ratio supplies a means of making allowance, in the comparison of two groups, for any difference there may be in the mean pigmentation, and if after making this allowance the one group is still more variable than the other, it may be concluded that approximately the same result would have been obtained, whatever system of colour grades had actually been employed. The following table shows the actual values obtained in calculating this allowance.

TABLE 4.

	Males.		Females.	
	Sum of Squares.	Sum of Products.	Sum of Squares.	Sum of Products.
Abundant . . .	13·013	+5·0939	15·009	+1·9626
Common . . .	18·888	+4·5609	32·768	+3·1099
Less than common . .	16·213	−0·4063	11·576	−0·5377
Total	48·114	+9·2485	59·353	+4·5348
Ratio	+0·1922		+0·0764	

In both sexes the sum of the products is positive, showing that either owing to the colour scale employed, or as a general fact in the group concerned, the darker species do generally appear to be the more variable. The difference between the ratios obtained for females and for males may be ascribed at least for the major part to the darker average tint of the former; the scale being apparently most open at about grade 7, and necessarily allowing less variability to show itself as the mean tint approaches the extreme grades.

The above method indicates that for each grade of colour an allowance of 0·1922 should be made in the standard deviation of the males, and of ·0764 in that of the females. These allowances probably suffice amply to obtain results which shall be practically independent of the colour scale; however, in view of the difference in the allowance which appears to be necessary for the two

sexes it has been thought worth while to calculate afresh an allowance, to be the same in both sexes, which depends not only on the colour grade but on its square. Allowing each of the six classes made by the three degrees of abundance and the two sexes, to determine its own mean, the regression was found in the form

$$+ \cdot 51490x - \cdot 032943x^2$$

where x is the grade number. For the mean values of the males and females, 5·35 and 6·65, this formula is equivalent to the simple regressions 0·1624 and 0·0768, agreeing thus very satisfactorily with the two values previously obtained.

The mean standard deviations, making allowance for the mean tint of each species come out as follows :—

TABLE 5.

Males.					Females.				
	A.	B.	C.	Mean.		A.	B.	C.	Mean.
1	—	1·131	1·875	1·503	1	—	1·220	2·060	1·640
2	1·635	1·189	1·368	1·402	2	1·824	1·548	1·324	1·606
3	1·585	1·256	1·052	1·222	3	1·741	1·559	1·341	1·484
4	—	1·764	1·047	1·406	4	—	1·443	0·956	1·200
Mean	1·620	1·249	1·212	1·341	Mean	1·799	1·516	1·361	1·568

as reduced by the quadratic formula to equivalent standard deviations for grade 6. It is a matter of indifference, for the comparisons, to which grade the standardisation is made.

There is evidently still a very substantially greater variability among the females, after allowing for the fact that this variability is liable to be measured in a dffierent part of the scale. Of the 35 species only 8 (against 27) have an adjusted standard deviation larger in the male, and in only 4 of these (against 18) does the difference exceed 0·25.

In consequence of the high correlation which exists between the variabilities of the males and females of the same species, the 35 differences between the sexes afford a precise test of the significance of the effect of sex. For other comparisons it is necessary to compare different species, and the sampling errors involve not merely the differences in sexual differentiation, but the much larger differences in variability which exist between different species. Hence although the differences are absolutely greater, their statistical significance is much less pronounced. The best available basis of comparison will be afforded by the variability observed between species classed alike both as to abundance and as to range. The estimates of the variance between species of the same class obtained in this way are 0·3802 for the standard deviations of males, and 0·2147 for that of females. In view of these values the difference between classes of different range cannot be judged significant, although the general tendency, in both sexes, for the species with the wider range to be more variable in the district sampled, suggests the possibility that there is here a real effect which more extensive data might bring out. With respect to abundance the difference in the females between the variability in the abundant class and that of the other two classes together exceeds twice its standard error, and must therefore be regarded as significant, in the sense of not being ascribable to chance in the selection of the species. The additional fact that in both

sexes the three classes come out in order of abundance gives additional certainty to this conclusion. Since the precision of such a test must lose much by the roughness of the criteria by which the species are classified, we may conclude that an exact classification based upon actual numbers would have shown even larger differences in variability.

(5). The Theoretical Connection between Variability and Abundance. [R. A. F.]

Charles Darwin (*Origin of Species*, chap. ii), in studying the causes of variability, attempted a statistical investigation of material relating to a large number of different species of plants. He was, perhaps unfortunately, dissuaded from publishing his actual tabulations, but gained the concurrence of Hooker to the general conclusions that "wide ranging, much diffused, and common species vary most." Darwin was concerned to show that it was not merely that wide-ranging forms give rise to local varieties in reaction to different inorganic and organic environments, but also that, "in any limited country, the species which are most common, that is, abound most in individuals, and the species which are most widely diffused within their own country (and this is a different consideration from wide range, and to a certain extent from commonness), oftenest give rise to varieties sufficiently well marked to have been recorded in botanical works."

It has since been pointed out (Fisher, 1922) that, assuming Mendelian inheritance, the individual variation in a character showing continuous variation may be regarded as an equilibrium condition between the action of mutations, tending to increase variability, and of selections tending to diminish it. If in such an equilibrium the mutation rates, and also the selection rates, were the same for all species, then the variance would be proportional to the population of the species. We know of no reason for supposing that the mutation rates are different for species differing in abundance, but it is *a priori* probable that in abundant species individual survival is less fortuitous, and more selective, than in rare species; while it is easily demonstrable that in species in which a higher proportion of the total variance is ascribable to genetic causes, the effective selection will be more intense than in species in which the variance is to a larger extent ascribable to environmental variations. On these grounds we should expect the more abundant species to be, in fact, the more variable, though to an extent which can only be ascertained by observation.

Since many other circumstances besides abundance must influence the variability, the effect of this factor can only be expected to show itself as a statistical average of a considerable group of species. The data for 35 species presented with this paper thus seem to provide a decided confirmation of the conclusion arrived at on purely theoretical grounds; moreover, the fact that Darwin's observation with respect to "well-marked variations" should be equally applicable to continuous variation would be unintelligible if, as is sometimes assumed, continuous variation had some origin distinct from the familiar Mendelian mutations.

The theory does not provide an explanation of the difference in variability between the two sexes. It is true that in so far as the variability is due to sex-linked factors, there will be some tendency, in moths, for which the female is heterogametic, for the female to be the more variable, but this explanation is insufficient numerically to explain the large differences actually observed.

It has been shown (Fisher, 1922) that the effect of complete dominance, in any factor in which the proportion of recessive genes is represented by q will

be to retard the action of selection simply in the ratio $q : 1$. If, to make the simplest possible assumption, selection were to act with equal intensity on the two sexes, the corresponding retardation of the selection of a sex-linked factor would be

$$\tfrac{1}{3}(1 + 2q),$$

for of three sex chromosomes, two will be in the male, and subject to retardation. Now in the male, or in any case with an autosome, the variance contributed by any factor will be proportional to the product of the frequencies of the two phenotypes, namely to

$$q^2(1 - q^2),$$

and since with uniform selection, the frequency in any element dz is proportional to the differential element

$$= \frac{dq}{q(1 - q)}$$

the expression for the variance in the autosomal case will involve the integral

$$\int_0^1 \frac{1}{q} \cdot q^2(1 - q^2)\frac{dq}{q(1 - q)} = \int_0^1 (1 + q)dq = \frac{3}{2},$$

while for the male, with sex-linked factors, we shall have

$$\int_0^1 \frac{3}{1 + 2q} \cdot q(1 + q)dq = \frac{3}{2}\left(1 - \frac{1}{4}\log 3\right).$$

For the female, the product of the frequencies of the two phenotypes is simply $q(1 - q)$, giving the integral

$$\int_0^1 \frac{3dq}{1 + 2q} = \frac{3}{2}\log 3.$$

Now $\log 3 = 1{\cdot}0986$ so that the variance of the female is increased by 9·86 per cent. over the autosomal case, while that in the male is diminished by 27·47 per cent. for factors in the sex chromosome. If one mutation in 10 appeared in the sex chromosome, the variance of the two sexes would be in the ratio 10·0986 : 9·7253, differing by only about 3·7 per cent. The differences observed are 21 per cent., 39 per cent. and 23 per cent. in the three abundance classes, and are consequently considerably greater than could be explained by sex-linked factors. The only modification of the above assumptions which would make much difference would be to throw the whole weight of selection on to the male. This would tend greatly to increase the amount of sex-linked variance. Since, however, it should be possible to determine experimentally how much of the heritable variability of a species is sex-linked, it is useless to discuss hypothetical possibilities in advance of the necessary facts.

(6). Discussion of the Greater Variability of the Female Sex, and Related Problems, in the Lepidoptera. [E. B. F.]

The foregoing data have shown that the female moth is distinctly the more variable, the difference being about 30 per cent. for all degrees of abundance. It is probable that at least two main factors are responsible for this difference of variability between the sexes.

In all cases so far examined the female has proved to be the heterogametic sex in the Lepidoptera (see Schrader, 1928, p. 132), and it is reasonable to

suppose that this is a constant feature of the group. It has been demonstrated in the last Section that this condition must have the effect of increasing the variability of the female, but to an extent which is insufficient to account for the observed facts. We must therefore look for an additional cause for the excess of female variability.

It appears to us that this is to be found more in the physiological than in the genetic differences between the sexes. Many genetic factors react with the sex hormones, producing the well-known sex-limited inheritance. Further, it appears that the sex hormone of the male in the Lepidoptera has the effect of inhibiting the action of an undue proportion of the genes. For this there appears to be at present no explanation; but the fact seems to be evident from the frequency of unisexual polymorphism in the female, and its rarity in the male (as mentioned in Section 2) in those cases where the differences are large enough to be appreciated readily. We suggest that the excess of female variability, above the amount to be accounted for by sex-linkage, is an expression of this process operating in the group as a whole, and not merely in the more striking examples which have previously attracted attention.

That sex-controlled inheritance is of the ordinary Mendelian type, the operation of certain factor-pairs being inhibited in one of the sexes, has been clearly demonstrated for a number of species (*e.g.* by Fryer, 1913, for the mimetic *Papilio polytes*, L.; and by Goldschmidt und Fischer, 1922, for the non-mimetic *Argynnis paphia*, L.). As has previously been pointed out, this type of inheritance is common in mimetic butterflies, but the female is always the polymorphic sex; it appears actually to be unknown for the polymorphism to be restricted to the male. Female unisexual polymorphism is also found in large numbers of non-mimetic species, and in this case the same type of dimorphism may be present in many allied forms. For example: in the LYCAENIDAE numerous species have blue males and polymorphic females, these being either black or blue, with all intermediate stages; the reverse condition does not occur. In *Argynnis* and allied genera several species have monomorphic brown males with dimorphic brown or greenish-black females. In a number of species belonging to the genus *Colias* a similar condition occurs, the female being either yellow (like the male) or white. This has been worked out in detail by Gerould (1911) for the American *Colias philodice*, Godt., and shown to give a simple Mendelian segregation.

The last example appears to be of some importance, since it supports a possible alternative explanation of sex-controlled inheritance, which has some bearing on the present problem. This was put forward by Goldschmidt (1923). He says that "if there was a pigmentation factor in the Y chromosome which reacted together with the autosomal factor in such a way that the coloration only appeared in the simultaneous presence of both factors, the result would be the same [as the ordinary physiological interpretation], *i.e.* the coloration would only appear in the females, since they alone possessed the Y chromosome." He further says: "Evidence for the accuracy of this conception could be obtained if occasionally a factorial exchange took place between the X and Y chromosomes. In such a case males of the particular form would be possible whose heredity could easily be deduced. In the *Colias* form mentioned above white males are as a matter of fact occasionally observed (Gerould)." More recently a similar case has come to light in an exceptional white male of *Colias euxanthe*, Feld. (Hemming, 1926). There is thus some ground for Prof. Goldschmidt's hypothesis, although the hereditary behaviour of these exceptions is unknown. Considering, however, the unlikelihood of large numbers of autosomal genes having complementary factors in the Y chromosome, and that

rather rare examples of *male* unisexual polymorphism exist among non-mimetic species, as in the moth *Parasemia plantaginis*, L., the mechanism of variation which he suggests must be somewhat unusual.

We consider it possible, therefore, that sex-controlled inheritance is the result of two distinct processes. The one being due to one of the sex hormones inhibiting the action of certain genetic factors, the other (and almost certainly the rarer) to the interaction of genes in the Y chromosome with others in the autosomes. The latter type should give purely female unisexual polymorphism (except for occasional crossing-over); but it is extremely doubtful if it is sufficiently common to account for any considerable proportion of the observed excess of female variation. Why the action of the former type should result in more female than male unisexual polymorphism, as it appears to do, remains unexplained.

It must be mentioned that mimicry, and increased polymorphism of the female, of the type described above, is not confined to butterflies; it also occurs among day-flying moths. For example, PTEROTHYSANIDAE of the genus *Hibrildes* have non-mimetic slightly dimorphic males; the females, which are totally different, being polymorphic and regarded as mimetic (*Proc. Ent. Soc. Lond.*, 1918, p. cxxxiv); see the Appendix to this paper.

In conclusion we may discuss the significance of unisexual polymorphism and allied phenomena from another point of view. It must first be noticed that many butterflies with monomorphic females are mimetic in this sex only, and depart widely from the typical coloration of the genus, which is retained by the non-mimetic males. Such species are, therefore, further examples of the greater female variability discussed previously.

Neither this condition, nor that of the true unisexual polymorphism found so commonly in mimetic species, is *a priori* to be expected from the mechanism described above, which controls the relatively greater female variation. We have shown that the female is the more variable sex (1) owing to the fact that it is heterogametic in the Lepidoptera, and (2) that a number of genetic factors interact with the male hormones to inhibit their appearance in that sex, and (3) possibly owing to the occasional presence of factors in the Y chromosome. But none of these conditions might be expected to produce a *complete* inhibition of mimetic pattern in the male, and its full development in the female. Their result should be to *reduce* the variability of the male, with the consequence that this sex should follow the general trend of variation in the female, but lag behind it; *i.e.* the males would be expected to mimic, but less perfectly than the females. This condition is frequently realised. Although often restricted to the females, mimicry is quite common in both sexes, when the female is frequently the better mimic, thus confirming the expectation.

It would thus appear that, added to the greater female variability described above, some other factor operates to inhibit the appearance of any mimicry in the males of many species. This we believe may be some form of sexual selection. One of the chief functions of the male is to stimulate the female to copulation; this is most frequently performed by sight or smell, sometimes by touch and hearing; but the displays of an insect often combine several of these types; Richards (1927) gives a valuable summary of this subject. It is probable, therefore, that in certain cases selection in favour of keeping the males to a relatively constant type, in order that their sex should be recognised by the female and cause her the appropriate stimulation, outstrips any advantage which they might derive from mimicry. That the male can often dispense with the latter advantage, in cases where it appears to be of value to the female, is possible for three reasons. (1) One of the most dangerous periods in the

life of the female, when she is most exposed and most in need of any protection which mimicry might afford, is during the time she is laying eggs; the male is probably never exposed to any danger of corresponding severity in the imago state. (2) Many females are less active on the wing than the males, presumably owing to the large size of the body. (3) Since a single male can fertilise a number of females, a proportion of the males could always be killed off without affecting the numbers in the next generation. See Wallace (1865) and Poulton (1909).

We therefore believe that selection of this kind may partly be responsible for the complete lack of development of a mimetic pattern in the males of so many mimetic species. Whether or not it can be responsible, to a small extent, for the greater female variability as a whole remains an open question; though this seems unlikely in the nocturnal species.

(7). Summary.

1. The frequency distribution of depth of pigment in the ground-colour of the fore-wings of 35 species of British moths has been obtained by comparison of over 5000 specimens with a standard colour scale.

2. For comparison of variabilities of groups of different average tint the standard deviations have been adjusted to eliminate any arbitrary elements which might have been introduced by the scale employed.

3. The mean tint is darker in the females than in the males, and is also darker in the more abundant than in the less abundant species.

4. Even after adjustment the mean variance is about 30 per cent. higher in females than in males, and is in both sexes greatest in the abundant species, and least in those which are less than common.

5. It is also possible, though the difference is not in this material statistically significant, that the species with wider range are, in any one locality, the more variable.

6. The association of variability with abundance accords with an early generalisation of Darwin's, and with the theory that variability is determined by a balance between the influences of mutations and selection. This theory is insufficient numerically to account for the large differences in variability between the sexes.

7. In view of the frequency of polymorphism, and other marked variations, in the females as opposed to the males in Lepidoptera, it is suggested that the male sex hormones may inhibit the action of a number of the factors influencing the development of pigment, as in the well-known sex-controlled variation. The suggestion of Goldschmidt that there exist pigmentation factors in the Y chromosome capable of interaction with autosomal factors to cause pigmentary differentiation is an alternative view which may account for a few cases. This should result in purely female unisexual polymorphism [except for the possibility of occasional crossing-over between the X and Y chromosomes], but it is almost certainly an infrequent phenomenon. It is possible that sexual selection may, in part, be responsible for the complete inhibition of mimetic patterns in the males of certain mimetic species.

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(9). A List of the Lepidoptera examined, giving the Mean and Standard Deviation of each Sex for the Colour Grades used in the Classification. [R. A. F.]

	No. examined, ♂.	Males.		No. examined, ♀.	Females.	
		Mean.	S.D.		Mean.	S.D.
Agrotis segetum, Schiff.	67	4·90	1·017	85	7·99	1·905
Apamea secalis, L.	120	6·82	2·526	105	7·75	2·615
Orrhodia vaccinii, L.	83	6·52	1·533	71	6·96	1·808
Triphaena pronuba, L.	127	6·17	1·463	147	6·63	1·672
Taeniocampa gothica, L.	146	4·40	1·105	157	9·05	1·458
Taenicampa incerta, Hufn.	70	7·37	1·704	60	7·72	2·017
Xylophasia monoglypha, Hufn.	88	5·36	1·808	76	5·34	1·732
Miana strigilis, Clerck.	80 137	7·145	2·480	89 134	7·83	2·553
Noctua xanthographa, Fb.	105	6·48	1·415	62	8·32	1·607
Taeniocampa stabilis, View.	92	3·87	0·632	117	4·98	1·114
Hydroecia nictitans, Bork.	71	5·42	1·051	48	6·15	1·237
Agrotis corticea, Hb.	111	4·78	1·344	75	7·44	1·742
Agrotis tritici, L.	89	5·63	0·993	79	7·56	2·080
Bombycia viminalis, Fb.	49	2·71	0·456	56	3·60	1·073
Dianthoecia carpophaga, Bork.	50	3·42	0·883	59	3·29	1·260
Mamestra dentina, Esp.	52	4·69	0·961	81	6·69	1·221
Mamestra pisi, L.	54	5·56	0·984	52	6·31	1·229
Selenia bilunaria, Esp.	75	4·88	0·735	58	4·72	1·295
Amathes lychnidis, Schiff.	84	6·99	1·517	94	6·94	1·795
Luperina testacea, Hb.	76	5·80	1·592	67	6·49	1·870
Noctua rubi, View.	53	5·58	0·663	61	6·85	1·223
Feltia clerica, Butl.	64	7·42	1·867	33	9·48	1·460
Agrotis saucia, Hb.	80	6·89	1·955	58	7·28	2·159
Agrotis puta, Hb.	64	3·44	0·614	48	8·21	0·921
Eumichtis adusta, Esp.	41	6·10	0·663	47	7·13	1·153
Miana bicoloria, Vill.	64	4·53	2·631	65	5·43	2·318
Noctua dahlii, Hb.	35	5·11	0·676	30	7·14	1·113
Agrotis agathina, Dup.	59	5·46	0·502	49	6·10	0·941
Agrotis cinerea, Hb.	78	3·44	0·783	8	7·12	1·552
Agrotis cursoria, Bork.	46	4·89	0·900	54	5·50	1·270
Agrotis vestigialis, Hufn.	105	3·63	0·943	39	5·64	1·598
Omphaloscelis lunosa, Haw.	86	5·00	2·212	73	7·14	2·238
Selidosema ericetaria, Vill.	56	7·00	0	24	7·25	0·676
Taeniocampa munda, Esp.	32	4·63	0·492	26	5·04	1·148
Hydroecia crinanensis, Burrows.	54	5·33	0·952	97	5·66	0·912

(10). APPENDIX.

On the Male and Female Forms of the African Pterothysanid Moth *Hibrildes norax*, Druce. By Prof. E. B. POULTON. Plate XII.

When I read the typescript of my friends' paper it occurred to me that an account of the most polymorphic moth hitherto recognised would be of interest as an extreme example of variation in relation to sex. Of all known Heterocera, *Hibrildes norax* exhibits the nearest approach to such butterflies as *Papilio dardanus*, Brown, or *Charaxes etheocles*, Cram., with their numerous female forms. The females of the moth also follow those of the butterflies in their mimetic patterns, but any discussion of the degree of resemblance is better deferred until the forms themselves have been considered.

All the known forms of *H. norax* are represented on Pl. XII, which I owe to the great kindness and skill of my friend Dr. Eltringham. In this plate it will be seen that the differences between the males (figs. 1, 3, 5) are very small as compared with the females (figs. 2 (also 10), 4, 6, 7, 8, and 9). Nevertheless the males shown in figs. 1 and 5 were described as different species, *norax*, Druce, and *venosa*, Kirb., respectively, fig. 3 representing an intermediate form. Similarly figs. 2 (also 10), 6, 8, and 9 were respectively described as the species *crawshayi*, Butl., *ansorgei*, Kirb., *albescens*, Joic. & Talb., and *neavi*, Hampson. In addition to these, two new female forms *carpenteri* (fig. 4) and *sheffieldi* (fig. 7) are described in this appendix.

Sir George Hampson, in 1910, was the first to suggest, in the following passage, that these supposed species, so far as they were known at that date, were males and females of the single species *H. norax*.

" It seems possible that *H. venosa* is a *variety* of *norax* rather yellower with stronger streaks on the veins and an oblique shade across the apical area of fore-wing, and that *craushayi*, *ansorgei*, and *neavi* are all forms of the female, the two former having the terminal band of hind-wing narrow; *craushayi* has the fore-wing fulvous, the hind-wing with fulvous subterminal spots, *ansorgei* fuscous, with a broad whitish postmedian band, the hind-wing with white subterminal spots, whilst *neavi* has a very broad terminal band to hind-wing, the subterminal spots very small and either white or fulvous. All the forms were taken in one district by Mr. Neave except typical *ansorgei*, which he did not get, though some of the varieties approach it. . . ." (*P.Z.S.*, 1910, pp. 453, 454.) Dr. S. A. Neave, who had collected the moths which were the subject of Hampson's paper, wrote in confirmation :—" There is nothing in my experience in the field which would make improbable Sir George Hampson's suggestion that this species [*H. crawshayi*] and the new *H. neavi* are the females of *H. norax* and *venosa* " (*ibid.*, p. 454).

The evidence, brought forward above, that both the male forms and some of the female forms fly in the same area, has been much strengthened by the results obtained since 1910. The most striking of these are shown in the following table, which also includes, in the fourth locality (Petauke), a part of Dr. Neave's earliest material described in the 1910 *P.Z.S.*

It is reasonable to suppose that selection based on an increasing mimetic resemblance has played an essential part in developing and maintaining the three female forms *crawshayi*, *neavi* and *ansorgei*. Thus Dr. Neave writes of the first two :—

" Both *craushayi* and *neavi* are remarkable Acraeine mimics, the former of *Acraea natalica*, Boisd., the latter, with its heavy black margins to the secondaries, of *Acraea anemosa*, Hew.

Data of place and time. The specimens from the first and fourth localities are in the Hope Coll., the others in Brit. Mus.	♂ form *norax* (fig. 1).	♂ form *venosa* (fig. 5).	♀ form *crawshayi* (figs. 2, 10).	♀ form *neavi* * (fig. 9).	♀ form *ansorgei* (fig. 6).	Other ♀ forms.
Tang. Terr., Lulanguru (3766 ft.), 17 m. W. of Tabora. 1–31.xii.1917. G. D. H. Carpenter.	3	3	3		1	1 *carpenteri*, f.n. (fig. 4): like *ansorgei*, but with rich orange-ochreous F.W. bar.
N. W. Rhodesia, Solwezi. 1916 and 1917. H. C. Dollman.		1	1	1	1	
N.W. Rhodesia, Mwengwa. 1913 and 1914. H. C. Dollman.	1	2	1		2	
N.E. Rhodesia, E. Luangwa Distr., Petauke (2400 ft.). 1904 and 1905. S. A. Neave.	7	9 +1 in B.M.	6 +1 in B.M.	2		1 *sheffieldi*, f.n. (fig. 7): like *crawshayi*, but with much dusky suffusion of F.W. and dusky H.W.
Nyasaland, Mt. Mlanje. 1912–1914. S. A. Neave.		26	16		4	1 *albescens*, Joic. & Talb. (fig. 8): like *ansorgei*, but with white H.W.
Nyasaland, Mt. Mlanje, Luchenya R. 1913 and 1914. S. A. Neave.		9	7			
Port. E. Africa, Kola Valley. 5–8.iv.1913. S. A. Neave.		5	11		4	
Port. E. Africa, Ruo Valley. 2000 ft. 1913. S. A. Neave.		4	3			

* A coloured figure of the ♀ f. *neavi* is given in *P.Z.S.*, 1910, pl. xxxviii, fig. 18.

"I found both these species of *Acraea* extremely abundant at Petauke in the Luangwa valley, whence most of the specimens of *crawshayi* and *neavi* come. These moths only resemble the large Acraeas fairly well on the wing as their flight differs a good deal. At rest, however, the resemblance is remarkable, the moth resting hanging from a grass stem, etc., with wings folded above its back, *exactly* as the *Acraea* does." (*P.Z.S.*, 1910, p. 454.)

The fact that *crawshayi* is far more abundant than *neavi*, and indeed than any other female form of *norax*, will be made evident by a glance at the above table. Its abundance is correlated with that of *Acraea natalica* among the large Acraeas of S. and E. Africa. Thus Dr. Neave writes of it in N. Rhodesia as "a common species everywhere and at all seasons, more especially in the Luangwa valley, where it is quite the most dominant of all the larger

Acraeinae " (*P.Z.S.*, 1910, p. 26). The difference between the patterns of these two female forms of *norax* is, however, small, as shown by comparing figs. 2 and 10 (*crawshayi*) with 9 (*neavi*). The Acraeine models also exhibit a general resemblance to each other, a resemblance which may be so far intensified that the insects would probably be indistinguishable on the wing, as may be inferred from the representation, in *Trans. Ent. Soc. Lond.*, 1902, pl. xvi, of two butterflies taken by Dr. G. A. K. Marshall, F.R.S., in Mashonaland, fig. 10 being a male *anemosa*, and fig. 11 a female *natalica*. Dr. Marshall states that " the two species are very similar upon the wing, and that the resemblance is much closer in the case of the female *natalica* than the male, thus following the rule in mimicry, and confirming . . . the opinion . . . that the approach has been from the side of *natalica*." This latter species appears to have " adjusted markings of a type usual among Ethiopian *Acraeinae* in such a manner as to produce superficial similarity to *anemosa*, an *Acraea* in which a very remarkable and unusual appearance is the warning sign of exceptional defence against insect-eating animals " (*ibid.*, p. 493). Dr. Marshall indeed considers that *anemosa* is one of " the two best-protected members * of the genus," the other being *A. zetes acara*, Hew. (p. 413). It is of much interest, therefore, that the ♀-f. *crawshayi*, mimicking the Acraeine mimic, should be so much commoner than the ♀-f. *neavi*, mimicking the model—facts which may be reasonably explained by the far greater abundance of *natalica*.

It has already been pointed out on p. 381 that the mimicry of Acraeas by these female forms is especially developed on the under-surface and in the position of rest. The upper surface of the ♀-f. *neavi* (fig. 9), with its deeper sienna colouring and broad black margin to the hind-wing is, however, quite a good mimic of *anemosa*, while the paler sienna upper surface of *crawshayi* (figs. 2 and 10) may gain some advantage by a very superficial likeness to the *dorippus*, Kl., f. of *Danaida chrysippus*, L., and its mimics, such as the *inaria*, Cr., ♀ of *Hypolimnas misippus*, L.

This last suggestion receives some support from the fact that the only other ♀-f. which appears to be at all common, viz. *ansorgei*, was noted by Dr. Carpenter to be " on wing incipient *Aletis* or *chrysippus* mimic " (*Proc. Ent. Soc. Lond.*, 1918, p. cxxxiv). The specimen bearing this note is represented in fig. 6.

The three remaining female forms of *norax* are apparently extremely rare. I know of only two examples of *albescens*, one of *carpenteri* and one of *sheffieldi*.

The ♀-f. *albescens* (fig. 8) is a variety of *ansorgei* in which the pale sienna of the hind-wings has been replaced by white. On the wing it would probably present a superficial likeness to a black and white species of the Danaine genus *Amauris*, perhaps to a *Neptis* or to a day-flying moth (*Deilemera*).

The ♀-f. *carpenteri* (fig. 4) also represents a variety of *ansorgei*, described on p. 383. It does not seem to be a mimetic form.

The ♀-f. *sheffieldi* (fig. 7) is described on p. 383. The single example bears an MS. label, written by the captor, Dr. S. A. Neave, suggesting a possible mimetic resemblance to one of the female forms of *Acraea serena*, F. (*terpsichore*, L.)—an opinion supported by the comparatively small size of this female *Hibrildes*.

There is a curious rough resemblance between the variational steps which appear to have led to certain female forms of *H. norax* and *Papilio dardanus*,

* It is also probable that the greater variability of *natalica* has facilitated the mimetic approach from its side rather than from that of *anemosa*.

Brown, respectively—*ansorgei* representing *trophonius*, Westw.; *carpenteri*—*niobe*, Auriv.; and *albescens*—*hippocoon*, F. It is not to be supposed, however, that the sequences were the same; for, while there can be no doubt that *trophonius* arose from *trimeni*, Poult., the ancestral form of *hippocoon*, and itself, gave rise to *niobe*, there are no grounds for the belief that the corresponding forms of the moth developed in a similar order.

New female forms with a note on the ♀-f. albescens.

Hibrildes norax, Druce, **carpenteri**, ♀-f.n.—This female form resembles *ansorgei*, but the broad postmedian band of F.W. is sienna instead of whitish. The tint of this band is similar to that of the hind-wing, which is somewhat deeper than in *ansorgei* and *crawshayi*, although paler than in *neavi*. The terminal band of H.W. is broader than in *ansorgei* and the subterminal spots smaller and sienna instead of white.

Type (Pl. XII, fig. 4) in Hope Dept., Oxford Univ. Museum. The single example was taken 10 December, 1917, by Dr. Carpenter at Lulanguru, Tang. Terr.

Hibrildes norax, **sheffieldi**, ♀-f.n.—This female form is described by Sir George Hampson as a variety of *crawshayi* in which "the fore-wing is suffused with fuscous leaving some ochreous white in cell, as streaks on inner area, and as a broad postmedian band, the whole hind-wing being suffused with fuscous" (*ibid.*, p. 453). The subterminal spots of the hind-wing are very pale ochreous.

Type (Pl. XII, fig. 7) in Hope Dept., Oxford Univ. Museum. The single example was taken 2 March, 1905, at Petauke, E. Luangwa District, N.E. Rhodesia, by Dr. Sheffield A. Neave.

The ♀-f. *albescens*, Joic. and Talb. (fig. 8), was described from a single example taken by Mr. T. A. Barns, April 1922 (end of wet season), on the E. bank of the Luvua River (alt. 3000 ft.), 85 m. N. of Lake Mweru. It is represented much reduced on pl. lxxx [Fig. 80], fig. 10, facing p. 264 of Barns' *Across the Great Craterland to the Congo*, London, 1923. A single male, only differing from typical *venosa* "in the broader apical band on the fore-wing," was taken by Mr. Barns, March 1922 (mid-wet season), in the East Luvua Valley (4000–5000 ft.), 5 days N.E. of Lake Mweru. The authors describe these insects as male and female of *Hibrildes ansorgei*, Kirby [*norax*, Druce], *albescens*, subsp. nov. (*Bull. Hill Mus.*, vol. i, No. 3, 1924, pp. 558, 559). Dr. Neave's example of the same form, here represented in fig. 8, and shown in the tabular statement on p. 381 to exist in the locality (Mt. Mlanje), where numbers of both male forms and four *ansorgei* females were taken, leaves no doubt about the validity of their conclusion, which the comparison of figs. 6 and 8 will render evident, the patterns being similar and the only difference a substitution of white for orange in the hind-wing. The proximity of Mr. Barns' locality to that in which Dr. Neave collected in 1904–5, and the occurrence of the ♀-f. *albescens* far to the east in Nyasaland, renders it improbable, however, that a separate geographical race of *norax* exists in the Luvua River district.

Explanation of Plate XII.

All the figures are of the natural size.

Male and Female forms of *Hibrildes norax*, Druce (Pterothysanidae).

Fig. 1. Male form *norax*, Druce: taken 20 December, 1917, at Lulanguru, 17 m. W. of Tabora, Tang. Terr., by G. D. H. Carpenter.

2. Female form *crawshayi*, Butl.: taken 6 December, 1917. Locality and captor as 1.

3. Male form *venosa*, Kirb., transitional to *norax*: taken 5 December, 1917, by the same captor in the same locality as 1.

4. Female form *carpenteri*, f.n.: taken 10 December, 1917. Locality and captor as 1. (The type.)

5. Male form *venosa*, Kirb.: taken 27 December, 1917. Locality and captor as 1.

6. Female form *ansorgei*, Kirb.: taken 4 December, 1917. Locality and captor as 1.

7. Female form *sheffieldi*, f.n.: taken 2 March, 1905, at Petauke (2400 ft.), E. Luangwa District, N.E. Rhodesia, by S. A. Neave. (The type.)

8. Female form *albescens*, Joic. & Talb.: taken 8 February, 1913, on Mt. Mlanje, Nyasaland, by S. A. Neave (B.M. register, 1914–171).

9. Female form *neavi*, Hmpsn. (Paratype): taken 1 February, 1905. Locality and captor as 7.

10. Female form *crawshayi*, Butl.: taken 14 February, 1905. Locality and captor as 7 and 9.

H. Eltringham, pinx. *Vaus & Crampton, Ltd.*

THE AFRICAN PTEROTHYSANID MOTH *HIBRILDES NORAX*, DRUCE.

All the figures are of the natural size. Male (1, 3 & 5) and female (2, 4, 6—10) forms of *Hibrildes norax*. 1–6 are examples of forms taken in one locality; 7, 9 and 10 in another.

NEW BETHYLIDAE (HYMENOPTERA) FROM BRITISH COLUMBIA

By Oscar Whittaker.

[Read June 6th, 1928.]

Plate XIII.

The specimens upon which the following descriptions are based were all taken by the writer. The first captured specimens were sent for identification to Mr. Robert M. Fouts, of Washington, who returned them with the information that they represented hitherto undescribed species.

Subfamily Bethylinae.

Bethylus brachypterus, new species.

(Plate XIII, fig. 2, male.)

Male:—Body black; antennae basally light reddish-brown, becoming darker apically; coxae and femora black; front tibiae and all tarsi reddish-brown, middle and hind tibiae brownish, paler at the joints; tarsi with the apical joints dusky, claws bifid, black. Fore-wings brownish, venation yellowish-brown, stigma darker, radius long, apically bent forward towards the costal margin; the discoidal nervure indicated by a narrow, white, hyaline line; basally the wings are naked, apically (beyond the basal cells) clothed with short hairs. Hind-wings hyaline, clothed with short hairs. Head slightly longer than wide, about one and one-third times as wide as the pronotum, produced between the eyes, a short median carina between the antennae extending backwards as far as the front margin of the eyes; posterior angles rounded; ocelli small, in an equilateral triangle, the lateral ocelli separated by about twice their distance from the occiput; antennae basally filiform, gradually becoming filiform-moniliform apically; clypeus smooth, with a median carina; the whole of the epicranium covered with fine, alutaceous sculpture and widely-separated, shallow depressions, and with some scattered, long, erect, whitish hairs. Thorax two and one-third times as long as wide; pronotum with the sides straight, widest posteriorly, hind margin slightly emarginate; pronotum, mesonotum and scutellum with similar sculpture to that of the epicranium but lacking the depressions; propodeum laterally carinate, a large, irregular, shallow depression at the sides near the base; basally, except at the sides, coarsely and closely punctate, laterally and posteriorly with fine, incised sculpture, the posterior portion more or less linear and vermiculate, a median smooth line extending for about half the length of the propodeum. Abdomen elongate-oval, smooth, polished. *Length*, 4·0 mm. *Alar expanse*, 4·3 mm.

Female:—Similar to the male but brachypterous. The wing development varies considerably, leaving about one-half of the propodeum exposed or reaching to the anterior margin of the second abdominal segment. In the short-winged individuals the venation is reduced to a single cell, but in the longest-winged individuals two cells are present.

Length, 3·0 mm.–3·8 mm.

Described from one male taken 5th June, 1926, and sixteen females, one taken 5th July, 1925, and the others on various dates from May to September, 1926–27: all the specimens from Chilliwack, British Columbia.

Type and allotype in the writer's collection.

Paratypes: three in the collection of Mr. Robert M. Fouts, the rest in that of the writer.

Bethylus flavicornis, new species.

(Plate XIII, fig. 1, female.)

Male:—Body black; mandibles pale; antennae yellow; forelegs entirely yellow or pale yellowish-brown with the femora darker basally; middle and hind coxae and femora brown; middle and hind tibiae yellow or brown; claws pale or, in the dark-legged form, dusky. Head widest across the eyes, as wide as long, about one and one-third times as wide as the pronotum, posterior angles broadly rounded; ocelli small, in an equilateral triangle, the lateral ocelli separated by about twice their distance from the occiput; a median carina between the antennae reaching backward as far as the anterior margin of the eyes; antennae filiform; clypeus smooth, with a median carina; the whole of the epicranium covered with fine alutaceous sculpture and widely-separated, shallow depressions and with a few scattered, short, erect, whitish hairs. Thorax two and one-half times as long as wide; pronotum with the sides straight, widest posteriorly, posterior margin slightly emarginate; pronotum, mesonotum and scutellum with sculpture similar to that of the epicranium but without the depressions; propodeum laterally carinate, basally closely and coarsely punctate except for a smooth median area reaching almost to the posterior margin of the propodeum where the puncturation becomes somewhat shallower. Wings abbreviated, only reaching to the posterior margin of the propodeum, venation reduced to a single cell. Abdomen elongate-oval, smooth, polished.

Female:—Similar to the male.

Length, 2·5 mm.–2·7 mm.

Described from four specimens, one male taken 14th August, 1927, and three females taken 19th July, 1925, 5th June, 1926, and 18th September, 1927, all from Chilliwack, British Columbia.

Type and allotype in the writer's collection.

Paratypes: one in the collection of Mr. Robert M. Fouts, and one in that of the writer.

This species is remarkable in having the male as well as the female brachypterous. It is the first such species in the genus to be described. This and the preceding species are the first two representatives of this genus having brachypterous females to be described from the Nearctic Region; the only other known species being *B. syngenesiae*, Halliday, from England.

These two species are very closely related, but can be easily separated by the following characters.

B. brachypterus.	*B. flavicornis.*
Antennae apically darker than basally.	Antennae unicolorous yellow.
Mandibles black.	Mandibles pale.
Front femora black.	Front femora yellow or yellowish-brown.

Pseudisobrachium agilis, new species.

(Plate XIII, fig. 4, male.)

Male:—Black; mandibles, except basally, brown; scape black, pedicel testaceous, funicle blackish-brown; coxae black, trochanters and femora blackish brown, tibiae brown, tarsi yellowish. Head as wide as long, posterior angles and occiput broadly

rounded; vertex convex, depressed before the anterior ocellus and with a deep, crescentic sulcus bordering the lateral ocelli laterally; eyes prominent, hairy; ocelli large, in an equilateral triangle; clypeus with a median carina, and finely, arcuately striate; mandibles large, curved, tridentate, the outer tooth very large, the inner one minute; antennae densely pubescent, filiform; scape as long as first two funicular joints combined, pedicel short, subglobular, about one-third as long as first funicular joint, remaining joints subequal, longer than wide. Thorax two and one-half times as long as head; pronotum twice as wide across the posterior angles as its median length, narrow in front, widening posteriorly, sides straight, posterior margin deeply emarginate; mesonotum with four longitudinal grooves, the inner ones only extending about half the length of the mesonotum, posterior margin centrally carinate; scutellum with a transverse depression at the base; propodeum longer than wide, sides straight, posteriorly rounded, base and sides carinate and with a median carina extending for about half its length, the surface coarsely rugose; the whole surface of the head, pronotum and mesonotum covered with alutaceous sculpture and widely separated depressions; head and pronotum with scattered. erect, pale hairs. Fore-wings brownish, finely pubescent, venation brown, stigma rhomboidal, the extreme base white; radius long, curved basally, then running straight and parallel to the costal margin, basal nervure oblique, meeting the subcostal nervure remote from the stigma, other longitudinal and transverse nervures indicated by white, hyaline lines. Legs densely pilose, tibial spurs 1, 2, 2. Abdomen as long as thorax, elongate-oval, depressed, smooth and shining, the first two segments laterally with long, scattered, pale hairs, remaining segments with the whole surface similarly clothed.

Female:—Unknown.

Length, 5·0 mm.–5·5 mm. *Alar expanse*, 7·0 mm.–8·2 mm.

Described from eight specimens taken at Chilliwack, British Columbia in August, September and October, 1926–27.

Type in the writer's collection.

Paratypes: one sent to Mr. R. M. Fouts, the rest in the writer's collection.

Among the paratypes is one specimen, considerably smaller than the rest, measuring only 4·2 mm. in length.

Laelius occidentalis, new species.

(Plate XIII, fig. 3, female.)

Female:—Black; mandibles brownish; antennae black, the pedicel yellowish brown; coxae and femora, except the extremities, black; tibiae and tarsi yellowish-brown, apical joints of tarsi darker; fore-wings very faintly fumose, venation yellowish; hind-wings hyaline. Head very slightly longer than wide, vertex convex, posterior angles broadly rounded; clypeus with a carina between the bases of antennae; eyes bare; ocelli in a triangle, lateral ocelli separated by about twice their distance from the occiput; antennae filiform, scape robust, about twice as long as the pedicel, pedicel about twice as long as wide and slightly longer than the first funicular joint, the scape and pedicel with stiff, bristle-like hairs, the funicular joints subequal, very slightly longer than wide, apical joint conical. Thorax twice as long as the head; pronotum about one and one-half times as wide as long, sides straight, posterior angles acute, posterior margin emarginate; mesonotum short, half as long as pronotum—this character separates this species from *trogodermatis*, Ashmead, in which the mesonotum is only one-third as long as the pronotum, and *utilis*, Ckll., in which it is three-quarters as long—scutellum with a deep, transverse, laterally expanded fovea at the base; the whole of the vertex, pronotum, mesonotum and scutellum covered with fine, alutaceous sculpture and long, scattered hairs; propodeum with the sides straight, quadrate, almost as wide as long, lateral margins with two closely

approximate carinae, centrally with three longitudinal carinae extending the entire length of the propodeum and another on each side of them reaching to about the middle, sculpture between the central carinae rugose, between these and the lateral carinae transversely striate. Coxae, femora and tibiae clothed with long, black, bristle-like hairs, the tarsi with short, stiff, black hairs. Fore-wings with the marginal vein and radius very short; some erect black hairs on the veins, the disc pubescent. Abdomen slightly longer than the thorax, elongate-oval, acutely pointed, polished, with very long, scattered hairs on the dorsum and sides, except the first segment.

Male:—Unknown.

Length, 3·7 mm. *Alar expanse*, 5·3 mm.

Described from a single specimen taken on a window at Chilliwack, British Columbia, 24th June, 1926.

Type in the writer's collection.

Subfamily Anteoninae.

Gonatopus foutsi, new species.

(Plate XIII, fig. 5, female.)

Female:—Head black, clypeus yellow; antennae with the scape and second joint pale yellowish-brown, remaining joints gradually thickened and becoming black towards the apex; thorax and abdomen black; fore legs with the coxae dorsally black, ventrally yellow; femora brownish-black, paler apically; trochanters and tibiae brown; tarsi brownish-yellow, empodium dusky; middle and hind legs with the coxae and femora brownish-black, apically paler; trochanters and tibiae brown; tarsi somewhat paler, apical joint dusky. Vertex feebly concave; vertex and pronotum very finely rugulose, remainder of the thorax more coarsely so; pronotum transversely-dorsally constricted. Abdomen smooth, polished.

Male:—Unknown.

Length, 3·0 mm.–3·5 mm.

Described from eight specimens taken at Chilliwack, British Columbia; one 8th August, 1924; the others in July and August, 1925 and 1927.

Type in the writer's collection.

Paratypes: one in the collection of the United States National Museum (Cat. No. 40,415); two in Mr. R. M. Fouts' collection, and the rest in that of the writer.

It gives me great pleasure to name this species after my friend Mr. Robert M. Fouts, and I gladly avail myself of this opportunity to express my sincere thanks to him for much valuable help on numerous occasions.

Gonatopus septentrionalis, new species.

Female:—Head black, clypeus yellow, antennae basally yellowish becoming dark brown apically; thorax and abdomen black, the latter smooth and polished; fore legs pale yellow, the coxae dorsally blackish at the base; femora brownish-black, the apical half pale yellow; middle and hind legs yellowish, coxae, except apically and femora basally, brownish-black, apical joint of tarsi dusky. Vertex decidedly concave, anteriorly smooth, posteriorly microscopically reticulate; pronotum with a transverse-dorsal constriction which is evanescent medially, finely alutaceous with a smooth median area, rest of the thorax finely rugulose.

Male:—Unknown.

Length, 3·25 mm.

Described from a single specimen taken at Chilliwack, British Columbia, 25th July, 1925.

Type in the writer's collection.

This species and *G. foutsi* run to *cyphonotus*, Bradley, in the Keys of Kieffer (Das Tierreich, Lieferung 41) and Fenton ("The Parasites of Leaf Hoppers," Ohio Journal of Science, vol. xviii), from which they are readily distinguished by the dorsally rugulose thorax.

Aphelopus microtomus, new species.

(Plate XIII, fig. 6, female.)

Female:—Black, mandibles and face, to just above the base of the antennae, pale yellow, the pale coloration continued upward for a short distance along the margin of the eyes; antennae with the scape yellowish, pedicel brownish-black, first five flagellar joints black, apical three joints palish brown. Front and middle legs yellow, apical joint of tarsi dusky, hind legs with the coxae, trochanters and base of femora yellow, apical half of femora brown, tibiae and tarsi paler brown, apical joint of tarsi dusky—one paratype has the hind legs, except the apex of the femora, yellow. Head two and one-half times as long as its median length, frons rounded, posterior angles rounded, occiput deeply emarginate and centrally carinate; frons with a median groove extending upwards towards the anterior ocellus, but not far enough to be visible from above; ocelli conspicuous, in a right-angled triangle, lateral ocelli slightly further apart than from the eyes and occiput; antennae with the scape slightly longer than the pedicel, joints three, five and six equal, one and one-third times as long as the pedicel, joint four one and a quarter times as long as joint three, joints seven, eight and nine equal and slightly shorter than joint three, apical joint as long as joint four. Thorax four times as long and about three-quarters as wide as the head; pronotum short, visible from above; mesonotum with distinct parapsidal furrows, posteriorly convergent but not reaching the posterior margin, and with a longitudinal carina exterior to the parapsidal furrows. Head, pronotum, mesonotum and scutellum finely reticulate, the scutellum with a smooth median area; postscutellum smooth; propodeum coarsely, reticulately rugose. Abdomen as long as thorax, much compressed, smooth, shining. Wings finely pubescent and ciliate; costal and subcostal nervures yellow; stigma and radius brown, the stigma darker, large and obliquely truncate apically, radius about as long as stigma.

Male:—Unknown.

Length, 2·1 mm.–2·2 mm. *Alar expanse*, 4·0–4·3 mm.

Described from four specimens taken at Chilliwack, British Columbia, 24th May, 1926 (two), and 5th June and 19th August, 1927.

Type in the writer's collection.

Paratypes: one in the collection of Mr. R. M. Fouts, the others in that of the writer.

This species runs to *comesi*, Fenton, in that author's key ("Parasites of Leaf Hoppers," Ohio Journal of Science, vol. xviii), but differs in antennal structure as well as colour.

Aphelopus plicornis, new species.

Male:—Black; mandibles reddish, paler apically; fore legs yellow; middle and hind legs brown, the femora darker, coxae black; apical joint of fore tarsi dusky. Ocelli conspicuous, in a triangle, the lateral ocelli nearer to the eyes than to each other and separated by about twice their distance from the occiput; occiput deeply emarginate. Antennae black, clothed with erect black hairs; scape and pedicel equal, slightly shorter and thicker

than joint 3; joints 4–9 very slightly longer than joint 3; apical joint one and one-half times as long as the preceding joint. Head, pronotum and mesonotum alutaceous, parapsidal furrows distinct, posteriorly convergent, becoming obsolete on the disc of the mesonotum, a fine carina external to the parapsidal furrows running from the hind margin towards the humeral angles of the mesonotum. Scutellum more finely alutaceous than the mesonotum; postscutellum smooth. Head and thorax with scattered pubescence. Propodeum coarsely reticulate. Abdomen much compressed, smooth and polished. Wings with fine pubescence and marginal cilia; venation brown, the stigma darker, large, obliquely truncate apically, radius slightly curved, as long as the stigma.

Female :—Similar to the male.

Length, 2·0–2·25 mm. *Alar expanse*, 4·5–4·75 mm.

Described from three males and ten females taken at Chilliwack, British Columbia on various dates between 9th June and 19th August, 1927.

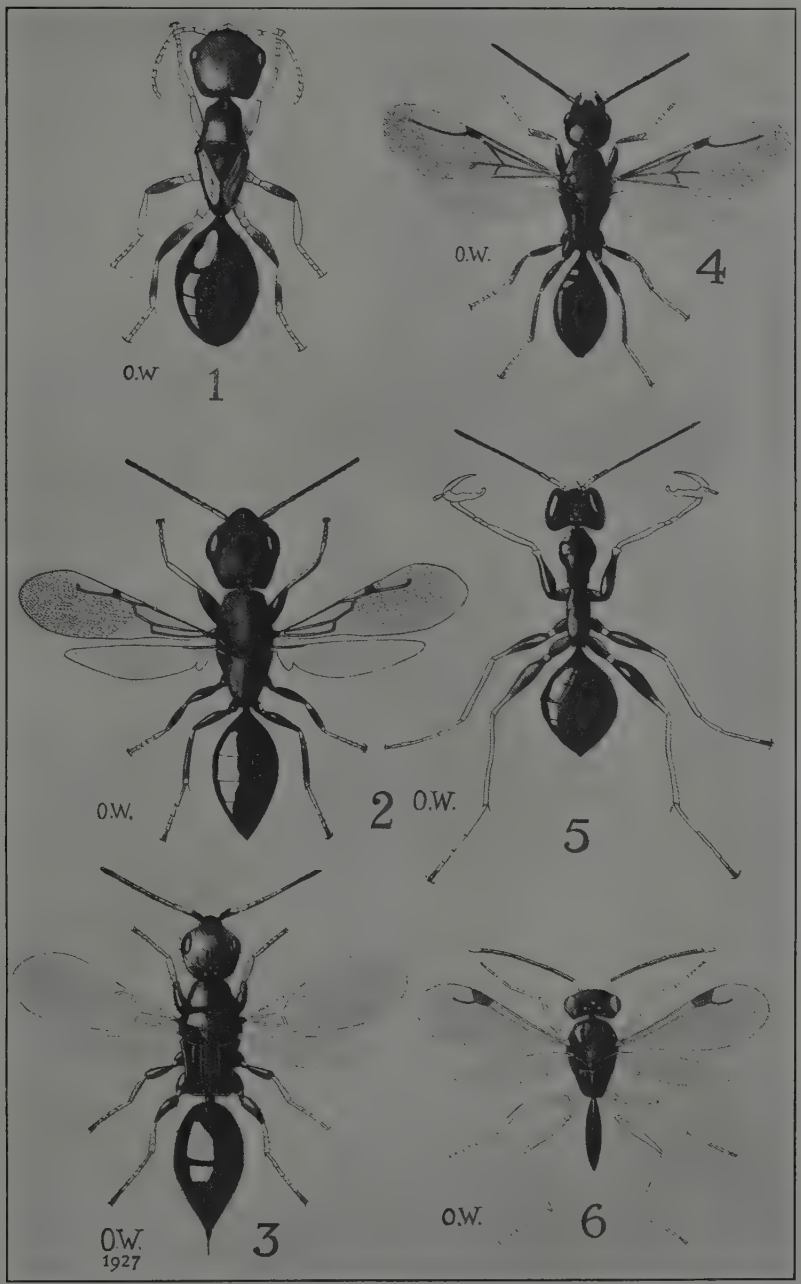
Type and *allotype* in the writer's collection.

Paratypes: four in the collection of Mr. R. M. Fouts, the rest in that of the writer.

Differs from *arizonicus*, Perkins, and *viduus* Perkins, in having the frons entirely black.

Explanation of Plate XIII.

Fig. 1. *Bethylus flavicornis*, n. sp. Female.
2. *Bethylus brachypterus*, n. sp. Male.
3. *Laelius occidentalis*, n. sp. Female.
4. *Pseudisobrachium agilis*, n. sp. Male.
5. *Gonatopus foutsi*, n. sp. Female.
6. *Aphelopus microtomus*, n. sp. Female.



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NEW BETHYLIDÆ FROM BRITISH COLUMBIA.

OBSERVATIONS ON THE BIONOMICS OF THE LEPIDOPTERA OF MATTO GROSSO, BRAZIL

By C. L. Collenette and G. Talbot.

[Read June 6th, 1928.]

Plates XIV–XIX and One Text-figure.

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1. ON SOME MIMETIC COMBINATIONS OF BUTTERFLIES OBSERVED.

By C. L. Collenette.

The insects dealt with in this paper were taken in Matto Grosso during the period April–November, 1927. They are listed in tabular form on page 401, and seven of the eight localities dealt with are indicated in the accompanying sketch-map. (See p. 392.)

It was first proposed to confine the account to butterflies captured in the locality alluded to as "Rio Serragem," but the remainder have been included for comparative purposes and to illustrate certain remarks on the insects dealt with.

Of the species mentioned, an endeavour was made to take every specimen seen.

Rio Serragem locality.

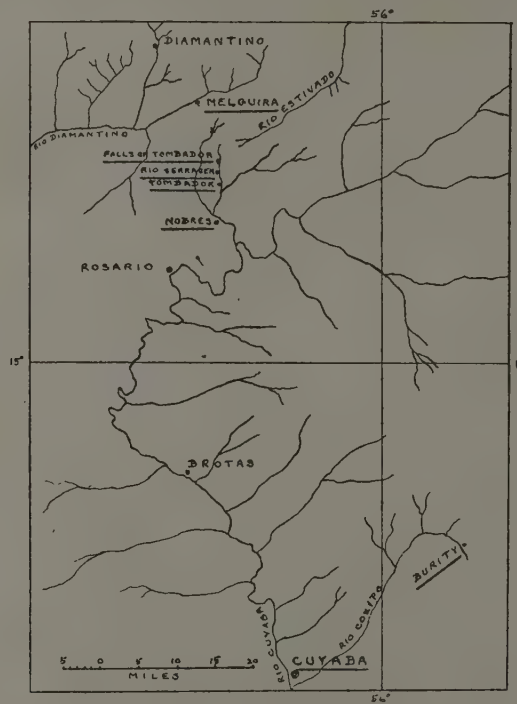
The small stream named the Rio Serragem rises on the plateau separating the basin of the Amazons from that of the Paraguay, and flows southward and over a line of cliffs, the fall being known as the "Tombador." It afterwards follows a winding course down a valley for some three miles, when it passes the *sitio* (or farm) of Tombador, which takes its name from the falls.

The writer explored both banks of the stream from the *sitio* to the falls, finding very dry and somewhat open forest interspersed with stretches of thickly growing bamboo and closely set Wakuri palms (*Attalea* sp.). The stream ran between high banks, sometimes developing into rocky cliffs, which supported little vegetation.

At a spot roughly midway between the *sitio* and the falls a tiny tributary entered the Serragem, and for the last 150 yards of its course and for a breadth of some 50 yards the vegetation was of an entirely different character, consisting of a number of large trees, the space beneath them covered with ferns and small straight saplings, largely free of obstructing leafy growth. I satisfied myself that this "oasis" was without parallel at any spot in the valley between the *sitio* and the falls, its nature being due to considerable moisture in the soil,

which received the drainage from small cliffs rising at a short distance back from each bank of the tributary.

In this small area, with its sharply defined boundaries of cliff, many butterflies were flying which exhibited mimetic coloration, and of which I met with no other specimens for a distance of $1\frac{1}{2}$ miles up and down the Rio Serragem. It therefore offered a rather unusual opportunity for establishing the relative numbers of the species and obtaining notes on their behaviour and habits. The first few storms heralding the wet season had taken place, and the month



Sketch-map of Cuyaba district, showing localities in which collections were made.

(August) was a favourable one as regards the number of species flying. I am of opinion that even during the rains of later months few of the insects would enter or leave the locality, owing to the brighter light in the surrounding forest and the unattractive vegetation.

The following is a list of species taken in the area during eight days between 12th and 27th August. No mention is made of sundry other species (Papilios, Morphos, Satyrids, etc.), some of which were also present in the surrounding forest and of which the total catch numbered 32 specimens. Single examples of two Pericopid moths, *Eucyane plagifera*, Feld., and *Pericopis catilina*, Crm., were also taken, which do not appear to be members of any mimetic combination seen there. It is noteworthy that no *Melinaea* or *Protogonius* was

met with in this or any other locality in Matto Grosso, and I have not been able to find mention of any species of these two genera taken in the State.

LIST OF SPECIES TAKEN IN THE RIO SERRAGEM LOCALITY.

	August, 1927.								♂.	♀.	Total.
	12th	14th	16th	18th	20th	24th	25th	27th			
MECHANITIS COMBINATION.											
PIERIDAE.											
Dismorphia astynome, Dalm.							1		1		1
DANAINAE.											
Lycorea ceres atergatis, D. & H.	4	1	3	6					11	3	14
ITHOMIINAE.											
Hirsutis pseudonyma pseudonyma, Stgr.	4	11	15	9	6	11	5	7	45	23	68
Mechanitis polymnia angustifascia, Talb.	50	57	60	38	29	26	4	9	177	96	273
Mechanitis elisa connectens, Talb.	47	51	40	36	24	15	3	14	156	74	230
Mechanitis lysimnia, Fab.				1						1	1
Ceratinia cantobrica pamina, Hnsch.	42	44	32	27	18	30	19	17	85	144	229
Sais rosalia brasiliensis, Talb.	1		2	1	2	4	1	2	6	7	13
Pseudoscada collenettei, Talb.	1		1	1		1			2	2	4
	149	164	153	119	79	87	33	49			833
TRANSPARENT ITHOMIINE COMBINATION.											
ITHOMIINAE.											
Episcada hymenaea hymenaea, Prittw.				2					1	1	2
Pseudoscada arzalia, Hew.	22	24	37	22	26	22	14	13	81	99	180
Heterosais edessa nephele, Bates.	5	5	11	9	12	11	8	4	33	32	65
	27	29	48	33	38	33	22	17			247
ITHOMIINAE.											
Dircenna dero dero, Hbn.	2	2		1	1	1	1		5	3	8
Dircenna zelie epidero, Bates.	1									1	1
	3	2		1	1	1	1				9
ITHOMIINAE.											
Aeria olena, Weym.	30	33	25	23	5	3	3	4	82	44	126
NYMPHALIDAE.											
Eueides vibilia unifasciatus, Butl.				1						1	1
											Total 1216

Average temperature : 7 a.m., 71°. Noon, 90½°. 6 p.m., 84°.

Excluding a few hours on the 11th August, which I devoted to cutting out low-growing thorny creepers and in exploring the upper reaches of the tributary, I arrived on each occasion at the spot about 8.30 a.m. and left at about 3 p.m. The first half-hour was usually devoted to observation. On the first three days the catch was limited by the number which could be conveniently netted and papered in the time. On subsequent days the surviving insects had to be followed into the more difficult portions of the locality, which involved much wading in the rocky bed of the tributary and climbing the detritus at the base of the small cliffs. On the final day the catch certainly contained some insects which had emerged since the previous visit, but only occasional captures were made after the first three hours, very few remaining unnetted when I left for the last time.

In no case did I see an insect leave the shelter of the thicker growth or ascend the small cliffs, and none appeared to cross the 25 yards of open stream and sand at the lower end of the locality to the dry bamboos on the other side of the Rio Serragem.

In discussing the appearance presented by the above insects during life, it is necessary to emphasise the comparative twilight which existed under the trees. With Imperial Eclipse plates (H. & D. 650), the photograph of the forest (Plate XVII) was given a two seconds exposure with f. 10, and that of the tributary (Plate XVIII) a half-second exposure with the same stop. These exposures were made between 11.30 a.m. and noon on a sunny day, and in the open country 1/100th of a second would probably have been sufficient.

Mechanitis Combination. The nine species which I have placed in this section, so styled because *Mechanitis* predominates in point of numbers, appear to be an example of a Müllerian combination, with Batesian mimicry also entering in the case of one or more presumably edible species. It is characterised by an oblique yellow bar across the fore-wing, in some cases broken up into spots, and differing in the area covered.

In the poor illumination of the locality light colours such as yellows and whites were conspicuous, but details of fawns, blacks and browns were not clearly seen. Judging by my own failure to distinguish between several of the species when seen in flight at close quarters, I came to the conclusion that size, and similarity in the style of flight, were of greater importance in mimicry in this area than very exact resemblance in markings.

Discussing the species separately, *Lycorea ceres atergatis* (Plate XIV, fig. 3) and *Hirsutis pseudonyma* (Plate XIV, fig. 6) were quite indistinguishable from each other on the wing, but fairly easy to separate when settled by reason of the conspicuous dark loop on the hind-wing of the former.

Mechanitis polymnia angustifascia (Plate XIV, fig. 7) and *M. elisa connectens* (Plate XIV, fig. 8) were also indistinguishable on the wing and were liable to be confused when settled, the resemblance being accentuated by the fact that variation exists in the markings of each species.

Ceratinia cantobrica pamina (Plate XIV, fig. 10) and *Sais rosalia brasiliensis* (Plate XIV, fig. 12) were quite indistinguishable on the wing and at rest, the colour of the antennae being the difference most easily noted. The *Ceratinia* ♀♀ considerably outnumber the ♂♂ in the series taken.

The three couples enumerated above were readily distinguishable by size —large, medium and small. All had a very similar "fluttering, dancing flight," but in the first couple the flight was slightly stronger and more direct, with a superior power of acceleration when alarmed.

The six species had very similar habits, spending considerably more than

half of the period between 8.30 a.m. and 3 p.m. at rest on the tips of fern fronds and on the leaves of bushes, choosing by preference those which were isolated and jutting out from the mass, rarely above three or four feet from the ground. They flew freely in the deep shade, but not so frequently above the water of the tributary, which was broad enough to allow more light to penetrate. The largest couple was more often observed there than the others. On no occasion did I see any notice taken of flowers, either in this or any other locality in Matto Grosso, but flowers were of rare occurrence in the haunts of these butterflies.

All six species were of much the same wariness, and took to wing at some five yards from me when approached incautiously, and at perhaps one yard if more carefully stalked. This seemed to argue a considerable distrust of the resting position if danger threatened. A striking note was made as to their behaviour when alarmed. Each species accelerated its flight and made straight for the water of the tributary, crossing it at right angles for the other side. This action was not without exception, especially in the case of the *Ceratinia* and *Sais*, but was a regular habit of which I took considerable advantage.

These six species in flight might readily be taken for large, normal and dwarfed specimens of the same race by an enemy not too skilled in observation.

The single specimen of *Mechanitis lysimnia* (Plate XIV, fig. 9) was not noticed among the long series of *M. elisa* until the insects were set. The yellow spot at the apex of the fore-wing in *M. elisa* fades almost to white in some old and worn specimens, and, seen in the poor light of the forest, the difference in appearance of the two species must be very slight. I met with no other specimens of *M. lysimnia* in Matto Grosso.

Dismorphia astynome (Plate XIV, figs. 1 and 2) was not distinguishable on the wing by colour or markings from *M. polymnia* or *M. elisa*, but it could nevertheless be picked out as a different insect, for, while the same " fluttering and dancing flight " was present, the speed was noticeably swifter. Its acceleration on being alarmed was also greater, and it was not very easily caught. The two or three specimens which I saw at rest (in this and other localities), were betrayed at once by the different shape and perhaps by the considerable difference in ground-colour and pattern. The white patches on the wings of the male, so conspicuous in the cabinet, are covered and invisible during flight and when settled. I believe that this species is a member of the association, but the resemblance so far attained is only a rough one.

I have included *Pseudoscada collenettei* (Plate XIV, fig. 13) in this combination without hesitation, although in the cabinet it appears far closer to the transparent Ithomiine combination. The five specimens taken on the wing were in no case distinguished from *Ceratinia cantobrica pamina* until seen in the bottle. The *Ceratinia* in flight has a conspicuous yellow band and a rather indefinite suggestion of brown and black. The *Pseudoscada*, with a similar flight, also displays a prominent yellow band of the same shade and an indication of brown and black. The effect of the coloration of the latter species can be best judged by placing the insect above a dark background and viewing by reflected light, a proceeding which parallels conditions in the forest, throwing the yellow into prominence and destroying the appearance of transparency in the brown areas, which then appear of somewhat the same shade as those of the *Ceratinia*. The *Pseudoscada* is a better mimic within the combination than *Dismorphia astynome*. Only one specimen was seen at rest (which I missed by a mischance to the net), and was then readily distinguishable.

Transparent Ithomiine Combination. The three species here included are connected by close relationship.

Pseudoscada arzalia (Plate XV, fig. 5) and *Heterosais edessa nephele* (Plate XV, fig. 12) can be distinguished when flying by the larger size of the white band in the former, and in a good light by the smaller dimensions of the whole insect. They have much the same flight. Both species appear to the eye as a couple of dancing white spots, the black veining and margins practically invisible, only an occasional glint being reflected by the polished surface of the hyaline portion. They were by no means easy to keep in view in the darker parts of the locality, but when in flight above the ferns bordering the tributary, which they largely frequented, were more conspicuous.

They did not usually fly across the tributary when alarmed, but made for the cover of a bush or a network of twigs. Owing to this habit they maintained their numbers in the face of my efforts better than other species.

The fragile *Episcada hymenaea* (Plate XV, fig. 2), which has no white band, was almost invisible in the half light of the forest. The first specimen flew closely past my face, and I netted it casually, thinking it a Micro or perhaps a Tipulid. Although I watched carefully for other specimens, only one was met with. It was seen for only a moment, but a series of quick strokes in the direction of its flight secured it.

These three butterflies are less conspicuous than the species in the *Mechanitis* combination, and the brown scaling on the wings of *Pseudoscada collenettei*, which separates the insect from the transparent Ithomiines, is very noteworthy.

Dircenna Combination. The two *Dircenna* (Plate XV, figs. 9 and 10) appear to occupy a place by themselves in coloration. In other localities in Matto Grosso they were sometimes taken in less shaded areas than those chosen by the *Mechanitis* combination, and there seems little reason to connect the two sections. However, although little resemblance can be traced in cabinet specimens, the following note was made in the Rio Serragem locality :—" Darker than *Mechanitis polymnia* and *elisa*, and the flight more rapid and direct, but a fairly close view is required to distinguish them with certainty." This casual resemblance may be the means of eventually drawing the *Dircenna* into the *Mechanitis* combination.

Aeria olena, Weym. (Plate XV, fig. 7.) This species flew with a steady regular flight, was very conspicuous, and made practically no attempt to put on speed or make for cover when alarmed. It will be seen from the table that the numbers present in the locality quickly showed the effect of my collecting. I met with no mimic of the species, but it belongs to a genus known to be distasteful, and its habits and appearance fully bear this out.

Eueides vibilia unifasciatus, Butl. The single female of this species was evidently a casual visitor. It had probably wandered down stream from a locality above the Tombador Falls, $1\frac{1}{2}$ miles away, which will be mentioned under another heading.

Urucum locality.

This locality, which is not shown in the sketch-map, is a range of wooded hills about 250 miles south of Cuyaba, and 15 miles south of the town of Corumba. During a period of two weeks in April and a further week in November I met with only *Lycorea ceres atergatis* (3 specimens) (Plate XIV, fig. 3) and one *L. halia* (Plate XIV, fig. 4). Several areas in this locality appeared perfectly suitable for others of the species dealt with in this paper,

and it is surprising that I did not come across them here or in other districts close to Corumba.

Cuyaba locality.

A long series of *Eueides vibilia unifasciatus*, with form *vibilia* in smaller numbers, was taken on rocky ground covered with low scrub outside the town. Many were congregated in the partial shade of two or three big isolated trees, but they also flew freely in the open sunlight. Associated with them was one specimen of *Actinote pellenea calymma*, which I noted as "closely resembling in flight a somewhat faded *Eueides*." The flight and habits of the *Eueides* were indicative of a distasteful species. Although the coloration of both *Actinote* and *Eueides* bears some resemblance to the *Mechanitis* combination, the different habitats would prevent a frequent meeting. It has been pointed out to me that although species may fly in different types of country, they may yet have common enemies, and the resemblance may perhaps have some Müllerian significance.

Nobres and Melguira localities.

The latter contains some elements of the "siringal" or rubber forest which stretches from the northern side of the plateau through to the Amazons. The butterflies of both areas were rather disappointing, presenting only occasionally seen examples of some of the species already mentioned.

Burity locality.

An area 30 miles N.E. of Cuyaba, on the plateau of Chapada, at about 2250 ft. Two visits were paid to this region, in June–July and Sept.–Oct., 1927. It will be seen from the tabular form, in which the two visits are separately listed, that far fewer insects were taken in Sept.–Oct.

The first storms of the wet season had taken place in August, but less rain had fallen at Burity than further to the north, and the forest in October was still drying quickly after a downpour. The insects dealt with in this paper were taken over a considerable extent of fairly thick forest, rather than in a single damp "oasis" as at Rio Serragem, and although the storms had brought out a large number of butterflies, including the shade-loving species, and the nightly catch of moths had passed its zenith, conditions in Sept.–Oct. were apparently not suitable for the Ithomiine groups.

Burity and the Rio Serragem-Tombador localities are 65 miles apart, and, for forest insects, are very definitely separated by large tracts of dry and open "campo." This "campo" is natural, due to conditions of soil and moisture rather than to any considerable clearing of forest. The greater elevation and exposure to wind at Burity results in a lower temperature, which in Sept.–Oct. averaged :—6 a.m. 67½°; noon, 83½°; and 6 p.m. 79½°. The average temperature in June–July at Burity is misleading, owing to short two- or three-day spells of really cold weather when the wind was in the south and south-west. Excluding these, the usual temperature was between 5 and 10 degrees less than in Sept.–Oct. A further distinction exists between the two localities in the occurrence of different species among the trees and plants.

Discussing the June–July period at Burity, it will be seen from the tabular form that nearly all the Rio Serragem insects were present, with the addition of several others, but in much smaller total numbers. The relative figures of each species at Burity are not very satisfactory, as the catch was made over an area of three or four miles and during the whole period of 33 days.

It will be noted that *Ceratinia nina chapadensis* (Plate XIV, fig. 11) is the dominant species in point of numbers in the *Mechanitis* combination, although it was not represented at Rio Serragem. A *Heliconius* has entered the combination which was also absent in the latter locality.

The same *Eueides* is present at Burity, together with form *vibilia* in small numbers, while a fresh *Actinote* appears. Here, as in other localities, they kept to open and slightly shaded areas, secondary growth and well-thinned forest, where they very rarely met with the other combinations.

Tombador Falls locality.

A small area just above the Falls and 1½ miles from the Rio Serragem "oasis," visited on four afternoons in August. Of very little interest, but yielding an occasional Ithomiine in some shady growth close to the river, and with several *Eueides* flying backwards and forwards over the water in the sun, of which I was only able to capture two specimens.

Tombador Sitio locality.

A narrow area, moistened by springs, bordering the river just below the *sitio* of Tombador, and also about 1½ miles from the Rio Serragem "oasis." The relative abundance of each species is again of less value than in the "oasis" series, as the totals are far smaller and the specimens taken almost daily over a period of five weeks. However, the two series are very similar, the most interesting difference being the relative commonness of *Sais rosalia* at Tombador Sitio.

Evidence of attack by Birds.

On reaching England and looking through the series of insects, I at once noticed a series of marks on the wings which could only be interpreted as made by the beaks of birds (Plate XVI). Mr. H. W. Parker of the Dept. of Zoology (Reptiles), British Museum, agrees with me that they are too pointed to have been caused by lizards, and called my attention to the fact that no teeth marks were visible. Other marks consisting of one, two or even three simple creases right across the wing have been caused by its bending or doubling up in a corner of the net during capture or by some accident during life. It is difficult to determine where one class of marking stops and the other starts, but adopting a very conservative selection there are 23 beak marks in 1184 specimens of the *Mechanitis* combination, 2 in 447 specimens of the transparent Ithomiines, none in the *Dircenna* and *Eueides-Actinote* combinations, and but one (rather faint and open to a possible doubt), in 153 *Aeria*.

A strong grip with a pair of entomological forceps leaves no mark on the wings, and the marks (which are in all cases clearly outlined and visible on both upper and under surfaces) appear to have been made, not by the power of the bird's grip, but by creasing of the wings in the insect's struggles to escape, slight movements of the bird's beak, and the weight of the insect. As might be expected, the side of the beak mark nearest to the insect's body is usually more pronounced than the other. An apparently identical mark occurs in nine cases, of a short broad beak (Plate XVI, figs. 4 and 5). In five other cases the mark is of a narrow beak (Plate XVI, fig. 2), these two series being probably the work of two single species. In three cases both wings are marked similarly (Plate XVI, figs. 1 and 2), showing that the butterfly was taken at rest, or possibly with wings together in flight.

Two species of bird were often seen to take butterflies in the open, a Jacamar, *Galbula rufaviridis*, Cab., and a Tyrant Flycatcher. In neither case did the beaks of these birds, when measured in the British Museum against the marks on the wings, coincide as to angle, and considering the very many insectivorous birds of the region it is not possible to run down the species. The hooked tip which many birds exhibit on the upper mandible is slightly indicated on some of the specimens.

The markings on each species are as follow :—

			Per cent.
4 marks on	96 specimens of	*Hirsutis pseudonyma pseudonyma*,	or 4·2.
8 „ „	344 „	„ *Mechanitis polymnia angustifascia*,	„ 2·3.
6 „ „	312 „	„ *Mechanitis elisa connectens*,	„ 1·9.
5 „ „	307 „	„ *Ceratinia cantobrica pamina*,	„ 1·6.
23 on	1184 specimens of the	MECHANITIS COMBINATION,	„ 1·9.
2 marks on	347 specimens of	*Pseudoscada arzalia*,	„ ·6.
1 „ „	152 „	„ *Aeria olena*,	„ ·6.

Comparing these with 1767 specimens of Matto Grosso butterflies outside the above series, excluding Skippers and Blues, and for the most part taken in open or sunny situations, we have :—

2 marks on *Heliconius erato phyllis*, Fbr.
1 „ „ *Papilio ariarathes gayi* f. *cyamon*, Gray.
1 „ „ *Amphidecta pignerator*, Btlr.

4 „ „ 1767 specimens, or ·23 per cent.

A striking and very puzzling predominance is shown in the markings on the insects of the *Mechanitis* combination, in view of the fact that during the eight days spent in the " oasis " in the Rio Serragem locality (from whence come 22 of the 23 marked specimens), I did not once see a bird. While watching the butterflies there and speculating on the Müllerian and Batesian theories, I looked around repeatedly for possible enemies of the insects, seeing none but a small herd of monkeys, which was usually present—this, although my diary is full of notes on the colours and habits of birds seen in the open and in other types of forest in the district.

Although the species in the *Mechanitis* combination seemed never to leave the shelter of thick shade after 8.30 a.m., I several times saw individuals crossing straight over the 20 or 30 yards of the river at the Tombador Sitio locality, and occasionally settling in the open, before 8 a.m. and when the sun had little power, this being at a time when sun-loving species congregating on the sand (very popular with the Tyrant Flycatcher and Jacamar) were not visible. It seems to me probable that the marked specimens of the *Mechanitis* combination were taken on the wing when making short flights over the river in the early morning.

This still leaves unexplained the large percentage of markings as compared with the insects of more open localities. On perhaps 13 occasions, of which 8 are noted in my diary, I saw a Jacamar catch a butterfly on the wing, generally a *Papilio* of the three very similar species *protesilaus*, L., *telesilaus*, Feld., and *orthosilaus*, Weym. If awkwardly caught, these were shaken and brushed against a bough until smashed. I did not see any specimens escape from the bird after being gripped. Reverting to the marked specimens of the *Mechanitis* combination I can find no examples which show a clearly severed

section of wing, such as might result if an insect had broken free from a beak. I have therefore thought that the marked specimens may have been purposely released by the birds, perhaps as a result of the close inspection, or taste or odour of the specimen, and possibly in an effort to find edible examples among a group which could not be separately recognised in flight. I am aware that this theory is founded on much that is speculative, but it appears to me as perhaps more feasible than any other explanation. Evidence of the rejection of distasteful species of butterflies by birds is to be found in *Proc. Ent. Soc. London*, 1912, p. lv, and 1913, p. xix, in some cases after the infliction of disabling injuries and in other cases with little damage.

I am indebted to Mr. J. J. Joicey for facilities afforded while working at the Hill Museum, and for kind permission to make use of the insects collected on his behalf; to Prof. Poulton for many helpful suggestions made both before and after the expedition; to Mr. G. Talbot, for much assistance rendered during the writing of the paper; and to Miss Cynthia Longfield, one of the two ladies who accompanied me during the earlier months of the expedition, for the loan of a number of specimens included with those dealt with in the paper. I have also to thank Prof. Poulton for authorising, from the Oxford University Fund for promoting the Study of Organic and Social Evolution, a grant in respect of the cost of illustrations accompanying this paper.

2. GATHERINGS OF BUTTERFLIES ON DAMP SAND, WITH NOTES ON THE ATTRACTION OF MOTHS TO HUMAN PERSPIRATION.

By C. L. Collenette.

During 1927 the writer spent eight months (April to November) in the State of Matto Grosso, Brazil, mainly on the plateau between the Amazons and the Paraguay, near the sources of the Amolar, Nobres and Coxipo. Assemblages of butterflies on damp sand were common, and were usually under daily observation.

Although the banks of a stream might provide a number of apparently suitable sandy or muddy patches, only those frequented by animals or human beings were regularly patronised daily by the insects. Several miles of the bank could be traversed without seeing an assemblage, although butterflies were flying freely up and down stream, until a place was reached where a track came down to the water. Spots where the washing of clothes was performed were the most popular. Fords were also much frequented. Horse and cattle manure, well beaten into the sand by animals using the fords, was selected by some species but definitely disregarded by the great majority, and little notice was taken of urine.

The assemblages commenced about 10.30 or 11 a.m. and attained their greatest numbers about 1 p.m., a few stragglers being present at 5.30 or even until sunset at 6.

The forming of an assemblage was watched on a number of occasions. The commonest species was *Catopsilia statira statira*, Cram., which would appear flying up the centre of the stream in small " follow my leader " parties, the insects behind reproducing every turn and dive of the one in front. The earliest arrivals usually went straight past the sandspit under observation, flying either up or down stream. Succeeding parties deviated more and more to the sand as the sun grew stronger, individuals settling for a moment here and there, only to rise and join the others as they circled round and flew away. If one remained on the sand for a few seconds others would join it and " test "

WITH NUMBERS TAKEN IN EACH LOCALITY.

	Urucum. 650 ft. 17/4/27–30/4/27 and 16/11/27–24/11/27.			Cuyaba. 1000 ft. 9/5/27–19/5/27.			Nobres. 1250 ft. 21/5/27.			Melguira. 2000 ft. 24/5/27–3/6/27.			Burity. 2250 ft. 11/6/27–14/7/27.			Burity. 2250 ft. 6/9/27–22/10/27.			Rio Serragem. 1500 ft. 12/8/27–27/8/27.			Tombador Sitio. 1500 ft. 24/7/27–28/8/27.			Tombador Falls. 2000 ft. 6–8 and 22/8/27.			Grand Total.		
	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total	♂.	♀.	Total
MECHANITIS COMBINATION.																														
PIERIDAE.																														
Dismorphia astynome, Dalm.													5	1	6				1		1		2	2				6	3	9
DANAINAE.																														
Lycorea ceres atergatis, D. & H.	2	1	3							1	1		1	1	2	1	2	3	11	3	14	1		1				16	8	24
„ *halia*, Hbn.		1	1										1	1	2													1	2	3
„ „ ab. *referrens*, Hnsch.														1	1							1		1				1	1	2
ITHOMIINAE.																														
Hirsutis pseudonyma pseudonyma, Stgr.								1	1				6	5	11				45	23	68	12	4	16				63	33	96
Mechanitis polymnia angustifascia, Talb.							5	1	6	3	1	4	1	2	3				177	96	273	33	25	58				219	125	344
„ *elisa connectens*, Talb.							2	2	4		1	1		1	1				156	74	230	46	29	75		1	1	204	108	312
„ *lysimnia*, Fab.																				1	1								1	1
Ceratinia cantobrica pamina, Hnsch.													2	5	7		2	2	85	144	229	23	46	69				110	197	307
„ *nina chapadensis*, Talb.													32	13	45	1		1										33	13	46
Sais rosalia brasiliensis, Talb.										1	1	2	1		1				6	7	13	8	7	15		1	1	16	16	32
Pseudoscada collenettei, Talb.																			2	2	4		1	1				2	3	5
NYMPHALIDAE.																														
Heliconius numata metalilis, Butl.													1	2	3													1	2	3
			4						11			8			82			6			833			238			2			1184
TRANSPARENT ITHOMIINE COMBINATION.																														
ITHOMIINAE.																														
Episcada clausina striposis, Hnsch.													1	1	2													1	1	2
„ *hymenaea hymenaea*, Prittw.																			1	1	2							1	1	2
Hypoleria consimilis, Talb.													10	1	11		1	1										10	2	12
Pseudoscada quadrifasciata, Talb.													4	4	8													4	4	8
„ *arzalia*, Hew.													35	28	63				81	99	180	49	55	104				165	182	347
„ *emyra*, Hnsch.													1		1													1		1
Heterosais edessa nephele, Bates																			33	32	65	6	4	10				39	36	75
															85			1			247			114						447
DIRCENNA COMBINATION.																														
ITHOMIINAE.																														
Dircenna dero dero, Hbn.													1	1	2				5	3	8					2	2	6	6	12
„ *zelie epidero*, Bates.													4	3	7		1	1		1	1							4	5	9
															9			1			9						2			21
AERIA COMBINATION.																														
ITHOMIINAE.																														
Aeria elodina, Stgr.																	1	1											1	1
„ *olena*, Weym.																			82	44	126	19	7	26				101	51	152
																		1			126			26						153
ACTINOTE-EUEIDES COMBINATION.																														
NYMPHALIDAE.																														
Actinote pellenea calymma, Jord.				♂	1	1																							1	1
„ *parapheles parapheles*, Jord.													2	5	7													2	5	7
Eueides vibilia unifasciatus, Butl.				121	35	156		1	1				9	9	18					1	1					1	1	131	47	178
„ „ form *vibilia*, Godt.				9	4	13							2	1	3													11	5	16
						170			1						28						1						2			202
			4			170			12			8			204			9			1216			378			6			2007

the surface, using the proboscis and walking slowly about. Usually these parties quickly broke up, but in this manner most of the sandy area near the water would be tested, often several times over. The butterflies did not appear to be guided by scent, but rather by taste and trial. Eventually, and perhaps an hour from the appearance of the first parties, two or three butterflies would remain settled until others joined them, when the assemblage would become permanent until disturbed by bird or man. (Plate XIX.)

On a hot sunny day, especially after rain, the gatherings would sometimes muster as many as 2,000 individuals, in a crowded, jostling mass. Butterflies flying up and down stream, and passing at a distance of anything up to seven yards, would suddenly deviate and settle straight among the others without any preliminary hovering or flying around.

The washing of clothes offered three possible causes of attraction—moisture, soap or perspiration from the clothes. Experiments showed that a weak solution of the soap used locally for washing was quite disregarded, while water thrown up from the stream to moisten the sand was little better, except to some of the Lycaenids and Hesperids. Furthermore, places were often chosen which were scarcely damp, whereas a few inches away water could have been obtained quickly and easily. On the other hand, if a handkerchief well soaked in perspiration were dipped in the river and then squeezed out on the sand, this spot became the most popular on the sandbank, nearly always to the exclusion of any other place on which the butterflies had settled. This attraction lasted as a rule for only one day, after which it had to be renewed.

When these gatherings were first under observation, I used to wait for perhaps an hour for the day's assemblage to form, but found later that it could be induced in a few minutes in the following manner :—A couple of *Catopsilia statira* would be caught, killed, and placed in a life-like position on the sand. Others would shortly fly down and join them, but after testing the surface would usually disapprove of the place selected and leave again. If, however, I had previously doctored the spot with perspiration as outlined above, allowing five minutes for it to soak into the sand and for the sun to warm it, the first arrivals would settle down at once and the assembly gather forthwith. This experiment was tried in several localities and on a number of occasions. If the dead butterflies were omitted the prepared spots might or might not be found, but their presence nearly always induced the first arrivals of the day to settle down. I never succeeded in bringing butterflies to a prepared spot on an *unfrequented* sandbank unless the dead insects were included. If they were added, and sufficient butterflies were flying past, its success was practically certain.

I saw no evidence of the employment of scent by the insects, but notwithstanding this, it was only at fords, etc., that the first butterflies of the day descended to test the sand. This seemed to point to some memory of the previous day's assemblage, and I am inclined to think that this was actually the case.

The presence of perspiration in minute quantities on the bank of a stream is not dependent on the washing of clothes. Man, domestic and wild animals have always bathed, drunk and crossed at convenient places, and, when they leave the stream, a considerable amount of perspiration, freed and remoistened by the water, drains from their legs into the sand.

In addition to the situations which have been mentioned, assemblages were also met with on moist patches in footpaths and roads. The gatherings were usually smaller in number and variety of species than those near the streams, and I did not keep any under careful observation. However, of the

many moist areas which appeared to be suitable, only those were frequented which were in the track of men or animals, and where the surface showed traces of footprints or hoofmarks. The selected spots varied very little from day to day, but in some cases the latest disturbance of the surface by men or animals may have been two or three days old. It therefore seemed probable that, as I have suggested above, a selected spot might be retained for a time by habit or by memory of the previous day's assemblage.

The following instances are selected, from among a number, to illustrate the manner in which a gathering place is transferred. At Burity, 30 miles from the town of Cuyaba, three spots in one small area were especially frequented by butterflies in the month of July, two of these being fords and the third a pigs' mud wallow. On a subsequent visit to the locality in Sept.–Oct., rains had commenced and one of the fords was disused, owing to springs having softened the banks, making access difficult. After animals had ceased to cross, only an occasional butterfly was to be found there, although the other ford, still in use, invariably attracted some hundreds. Further up this stream, a woodcutter built a hut and took up residence with his family during the month of August. Although I had seen no butterflies there during July, the place chosen by the family for washing and drawing water had a large daily gathering of butterflies by the time I returned to the locality in September. This spot was kept clean, and was never visited by domestic animals.

Perspiration as an attraction, or some constituent of it, may be compared with the "salt licks" on which gather males of *Troides brookiana albescens*, Rothsch., in Malaya (*Singapore Naturalist*, No. 2, April, 1923, p. 85), the "salt-licks" being preferred to other adjacent moist spots, although one cannot exclude the possibility that here also the attraction may have originated from the wild animals which trample the ground in these places.

In Matto Grosso it is the practice to put out coarse salt for the cattle and horses once or twice a week, and the inside of the open wooden trough is invariably wet with saliva when the animals have finished. No butterflies were seen to visit these troughs at any time.

Among the many accounts in entomological literature of butterfly assemblages on damp sand in the tropics, there is frequent mention of such assemblages at fords, and at places where the washing of clothes is performed. Many of these would seem to fall into the same category as those I have described, and my own recollection of gatherings in West Africa and Malaya points to the same origin. Other accounts make it clear that in some countries the insects are attracted often by the desire for moisture alone, as well as to manure and urine.

In the gatherings on damp sand which I have described, the commonest and most easily observed species did not appear to be guided to a favourable spot by scent, but rather by a system of test and trial conducted by many individuals. A garment hung up close to a sandbank attracted none of the species concerned in the sand assemblages, although they might be eagerly grouped not far away on a spot prepared with perspiration from the same garment.

Other species are attracted to human perspiration by scent, and into this category seem to fall a number of observations published in recent years. These observations relate chiefly to the HESPERIIDAE, but also to members of other families, attracted to the human skin, and to places where perspiration had apparently been deposited (*Proc. Ent. Soc. London*, 1916, p. lxxx, and 1917, p. lxxvii, also *Trans. Ent. Soc. London*, 1921, p. 407). The same observation was made regarding a Hesperid attracted to dried ink (*Proc. Ent. Soc.*, 1913,

p. xl), and the suggestion put forward that a study should be made of the composition of perspiration in relation to climate and mosquito attraction (*Proc. Ent. Soc.*, 1918, p. clxxiv). Another observation relates to butterflies of the African genus *Crenis*, which settled on the skin in numbers, apparently intent on perspiration, having been attracted thereto from a large gathering of the same species on the surface of a road (*Proc. Ent. Soc.*, 1927, p. 89).

Garments soaked in perspiration and hung up in the forest in Matto Grosso attracted several species, notably Morphos and Ageronias, and at least two species of Hesperid. In these cases scent was certainly employed, and two Morphos alighted on a handkerchief within ten minutes of its first display. Each garment usually attracted one or two butterflies in the course of a morning, but the species affected were not common ones, and experiments were consequently unsatisfactory. The Hesperids were frequently seen to apply moisture to the perspiration in the manner described in the above references, but although the garments were usually quite dry, no such action was seen with either Morphos or Ageronias. Both the latter were seen at moist spots on forest paths, and both were also attracted by animal manure. No butterflies were seen at any time on the coats of horses which were perspiring after work.

The forest haunting Pierid, *Itaballia demophile demophile*, L., was seen in Matto Grosso on several occasions assembled in numbers on dead leaves which covered the ground under large trees. The insects were usually somewhat scattered, and only males were present. A close examination failed to reveal the source of attraction.

Notes were made as to the behaviour and grouping of different species of butterfly on damp sand near streams. The following is a general summary, referring to the great majority of individuals and not to exceptional cases which were sometimes noticed. Furthermore, they relate only to the plateau of Matto Grosso, and not to the flat " pantanal " country to the southward, where different species were present in the gatherings.

The first list comprises those species which made up the main bulk of the assemblages. They followed each other to some extent in the air and associated closely on the sand without distinction of species.

Appias drusilla, Cram.
Daptonoura lysimnia bianca, Fruhst.
Catopsilia eubule sennae, L.
,, *philea philea*, L.
,, *argante argante*, Fab., and form *hirsilia*, Cram.
,, *trite*, L.
,, *statira statira*, Cram.
Gonepteryx menippe ab. *calypso*, Röb.
Dismorphia licinia, Cram.

The following often mixed indiscriminately in the assemblages, but were sometimes to be found apart in small gatherings of their own.

Papilio agesilaus autosilaus, Bates.
,, *protesilaus protesilaus*, L.
,, *orthosilaus orthosilaus*, Weym.
,, *telesilaus telesilaus*, Feld.
,, *thyastes thyastes*, Drury.
Terias thymetus, Fab.

The following were sometimes to be found in the main gathering, but always on its outskirts, associating with their own kind and sometimes forming separate patches of colour. They were attracted by perspiration, but apparently not by the presence of the main gathering, and I did not see any of them descend to dead Catopsilias on the sand.

Megalura chiron, F.
Caria castalia marsyas, Godm.
Lasaia agesilas narses, Stgr.
Leptotes cassius, Cram.
Two or three species of HESPERIIDAE (not identified).

The following were also to be found on the sandspits, some preferring wet sand and others a rather dry surface. None of them was seen to come to my artificially formed perspiration bait, and they were often scattered over the surface, returning to different spots after being disturbed. Notwithstanding this, they showed a distinct preference for sandbanks where washing was done or animals had passed. An examination of their settling spots led me to think that in many cases there was nothing but the plain moisture of the sand to attract them, but also that they could perhaps detect a foreign substance in the sand, caused by the traffic, in more minute quantities than could the species enumerated above. The first three Papilios in the list often settled closely together. *Papilio polydamas* was sometimes grouped with its own species and at other times scattered. The *Libythea* and the *Haematera* were frequently present in very large numbers, showing a tendency to associate with those of their own species, but at other times spread out over a considerable area. The other species in the list were usually solitary.

Papilio thoas brasiliensis, R. & J.
„ *lycophron phanias*, R. & J.
„ *androgeus androgeus*, Cram.
„ *polydamas polydamas*, L.
„ *pausanias pausanias*, Hew.
„ *ariarathes gayi* form *cyamon*, Gray.
„ *dolicaon deileon*, Feld.
Heliconius clytia clytia, Cram.
Colaenis julia, Fab.
Megalura peleus, Sulz.
Historis orion orion, Fab.
Eunica margarita ingens, Seitz.
Haematera pyramus pyramus, Fab.
Libythea carinenta carinenta, Cram.
Several HESPERIIDAE.

Six or seven species of *Callicore* and *Catagramma* were taken more commonly on damp sand than in any other situation, but notes on their habits in different localities differ so widely that they cannot be usefully summarised. The commonest species, *Callicore clymena janeira*, Feld., was not usually attracted by perspiration, but was often found in numbers on old deposits of horse and cattle manure, which it shared mainly with *Terias*, LYCAENIDAE and HESPERIIDAE. When the rains commenced in August, it gradually deserted the sandbanks in favour of the forest, where, in certain spots, it would commonly be found settled to the number of ten or twenty on the leaves of a single tree.

A number of other butterflies paid occasional visits to the sand. Some of these were scarce in the district and no continuous notes on them could be made. Others, such as the common *Heliconius erato phyllis*, Fab., and *Anosia erippus*, Cram., made rare appearances of short duration, apparently for the sole purpose of absorbing moisture during hot weather.

A series was taken of each of the species haunting damp sand. These were almost exclusively composed of males, but the following females were taken on the sand :—One each of *Daptonoura lysimnia bianca*, *Catopsilia statira statira*, *Haematera pyramus pyramus* and *Papilio thoas brasiliensis*, and two of *Leptotes cassius*.

Experiments were made on the sand gatherings with paper models. Pieces of white paper, torn to the shape and size of a butterfly and placed upright in the sand, induced an occasional insect to hover for a moment and investigate, but not to settle. My best attempts to imitate the colouring with painted paper succeeded better, but as I did not go the length of modelling the body, the results had a flimsy appearance and were only partly successful. The dead butterflies which I used seemed as attractive as if they had been alive. In these experiments I could find no evidence of the employment of scent, but only of vision.

A dead specimen of *Catopsilia statira* floating down the stream attracted the attention of others flying above. They would hover closely over it for several seconds and seemed occasionally actually to touch it. A floating *Catopsilia* was quickly taken by fish when it arrived at a deep pool.

Two species of bird were commonly to be seen perched on trees and bushes near the butterfly assemblages. One was a Tyrant Flycatcher, which fed sometimes on butterflies but more often on the other insects which swarmed on the sand. It would fly down and settle among them, look round for a moment, pounce on an insect and carry it into a tree. A *Catopsilia trite* was taken (identity certain), and swallowed wings and all in three or four gulps. Another capture appeared to be a *Catopsilia statira*. These were the only butterflies among twenty or thirty other insects which I saw taken, but I attributed to the work of this bird the wings of two or three *Papilio protesilaus* which I found scattered under its usual perch. The other bird was the beautiful Jacamar, *Galbula rufaviridis*, Cab., with long curved beak and brightly-coloured plumage. This, so far as my observation went, lived exclusively on butterflies, and could frequently be seen at work. Its method was to plane swiftly down from a branch, and with a loud snap of its bill catch a butterfly on the wing. It never rested on the ground, but occasionally made an unsuccessful snatch at a settled insect. Its favourite prey was one or other of the three very similar Papilios *P. protesilaus*, *P. telesilaus* and *P. orthosilaus*, probably the first of these, as the other two were not common. I have notes of seven attempts to catch these Papilios on the wing, of which four were successful, and others were unfortunately not recorded, to the number of five or ten. In all cases the butterfly was held by the body and shaken and brushed against a bough before being swallowed, and in only one instance were any of the wings broken off, and these fell into the stream. The Papilios on the sand were usually few in number among a large crowd of Catopsilias, yet they were obviously selected by the bird in preference to the others. In one instance a *Papilio pausanias* was chased high into the air, but was not captured. On another occasion three *Catopsilia statira* were taken in rapid succession by the same bird, two wings being dropped in one case but the others swallowed, no Papilios being present in the small gathering from which

they were taken. It is perhaps worth recording that I also saw the bird at close quarters with what certainly appeared to be an *Anosia gilippus gilippus*, Cram., in its bill. I did not see the insect in flight, and it was swallowed entire, and I quote the incident with some hesitation.

Dismorphia licinia was common in the gatherings of Catopsilias and Papilios, and the characteristic shape of the genus was not noticeable when it was settled. Its mimicry did not appear to be directed to any special species, but it was quite inconspicuous in an assemblage and difficult to pick out from the crowded insects.

The small lizards which swarmed in the bushes and driftwood surrounding a sandspit were never seen to feed on the butterflies.

The Attraction of Moths to Human Perspiration.

The most successful method of attracting moths at night in Matto Grosso was by means of human perspiration.

The method used was to hang up in trees and bushes a number of garments which had been previously worn. The freshness of the perspiration was immaterial, and when the same garments were hung up for several successive evenings, their power of attraction was increased rather than diminished. A garment rinsed in a stream to remove the perspiration was afterwards quite disregarded.

The table at the end of this paper shows, as an example, the catch of moths on 34 evenings in one locality. Of the 2044 insects collected, 29 were bred or taken with a net, 27 were caught on damp sand, 288 were taken at light, and exactly 1700 by means of perspiration in garments.

Damp sand was much less attractive than the garments, and over 90 per cent. of the moths seen on the sand were Geometers. They showed the same preference for fords, etc., as did the butterflies, but were less grouped and more scattered over the surface. Much the same numbers were present after rain, which seemed to show that moisture alone was not the attraction. It is possible, however, that the heat of the sun is necessary to bring out fully the attraction of small quantities of perspiration present in the sand. A rough count on an average evening in October gave 210 moths on an area of damp sand 20 yards by 4 in extent. Only a few specimens were actually collected from the sand, as the same species were more easily examined and bottled on the garments.

Taken on the garments was a large number of species that never appeared at light, but the latter was useful for those having a vestigial proboscis, which of course were never attracted to perspiration. The light consisted of two 400 candle-power petrol vapour lamps, with a screen of 8 ft. by 6 ft.

The garments which were used averaged 15 in number, hung at intervals of from 20 to 50 yards through open ground and forest. There was strong evidence that the moths were attracted from a comparatively small radius round each garment.

On some occasions upwards of 100 moths would be present on a single garment, and a count made during one " round " of 15 garments on an average evening (6th October) gave 246 specimens, of which 17 were taken. If the same proportion is used for the period of 34 evenings, the catch of 1700 moths gives over 24,000 as the number actually attracted.

The moths which came consisted of many species, the catch of 102 on Sept. 17th containing about 49, and that on Sept. 27th, with a catch of 120,

about 62 species. The falling off in the numbers taken towards the end of the list of evenings was due to a sufficient series of each of the commoner species having been secured. The full number of species taken by this means is not yet available, but a rough estimate of the moths seen on the garments, made at the close of the period, gave perhaps 45 per cent. of the total number as Noctuids, with Geometers 25 or 30 per cent., and Pyralids 10 or 15 per cent. Micros were not numerous, and there were no Sphingids. Ants and cockroaches were attracted in numbers, together with some crickets and grasshoppers, but no Cicadas or Coleoptera were seen.

Experiments were made with garments worn by different persons, including the coat of a negro, and those of several Brazilians of Portuguese and mixed descent. No difference from my own garments in the degree of attraction could be detected in any case. A cloth used in rubbing down a horse which had been working scarcely attracted a moth, and none was seen to settle on the hide of horses or cattle after dark. On one occasion three small Geometers were present at the same time in the eye corners of a horse.

TABLE OF MOTHS TAKEN AT BURITY, MATTO GROSSO, FROM SEPTEMBER 15TH TO OCTOBER 22ND, 1927, EXCLUDING DAY-FLYING SPECIES.

	Sundries.	Bred.	Flying over marsh (Sphingids).	At light.	On damp sand.	At perspiration.	Total.
Sept. 15th		3		26		7	36
16th			6	8		60	74
17th						102	102
18th			1			60	61
19th			4	1	1	80	86
20th			2		5	56	63
21st			5	2	4	64	75
22nd				7		92	99
23rd				4		96	100
24th			1	1	1	29	32
25th				1		107	108
26th				1	1	107	109
27th			1			120	121
28th	3			17	1	20	41
29th				26		25	51
30th		1		15		92	108
Oct. 1st				8	1	66	75
2nd				34		67	101
3rd				21		58	79
4th				2		11	13
5th			1	11	2	29	43
6th				10	1	47	58
7th				2		22	24
8th				3		23	26
9th	1			7	2	16	26
10th						13	13
15th				10		48	58
16th				5	1	36	42
17th				5	4	12	21
18th				19	2	30	51
19th				5	1	16	22
20th				10		42	52
21st				12			12
22nd				15		47	62
	4	4	21	288	27	1700	2044

A moonlight night made no noticeable difference in the numbers attracted to the garments, but the light of a lantern scared many of the insects.

If a garment were dipped quickly in a stream and hung up alongside a dry one, a slightly larger number of moths visited the former. This experiment was difficult to carry out on account of dew.

An interesting visitor to the garments was *Oxytenis modestia*, Cram., a member of a group (the OXYTENIDAE) formerly placed among the Saturniids, but distinguished from them by, among other features, the presence of a fairly strong proboscis. The proboscis in this species was undoubtedly used in feeding. The moth was present in some numbers, together with a Geometer, *Microgonia apidamia*, Cram., to which it bore a strong resemblance, and I did not realise for some time that I was dealing with separate insects.

During a trip in 1926 in French Guinea, West Africa, I frequently hung up garments in the evening to dry, as also did the porters who accompanied me, but no insects were seen to visit them. Although human perspiration is so attractive to moths in Matto Grosso and Eastern Bolivia, I have been unable to find any accounts of similar attraction in other parts of the tropics.

3. ON THE ODOUR OF TWO SPECIES OF *HELICONIUS*.

By C. L. COLLENETTE.

During the expedition a series of notes was taken on the odour of *Heliconius erato phyllis*, Fab., and *H. melpomene burchelli*, Poulton. (Plate XV, fig. 11.)

Neither species was really common, and the numbers secured, as shown in the list at the end of the paper, represent all that could be netted.

Each specimen was tested for scent while still in the net, the following standard being adopted :—

SLIGHT SCENT. Where no odour was perceptible until the insect was held close to the nose and carefully tested.

FAIRLY STRONG SCENT. Where the odour was plainly perceptible at once, from several inches away.

STRONG SCENT. In which the odour was perceptible as soon as the insect was in the net.

VERY STRONG SCENT. A single instance in which the odour was detected by another observer at a distance of 6 yards.

The two species were not recognised as such until after their arrival in England, which adds to the interest of the observation made on the odour of *H. melpomene burchelli*. The note on the single specimen recorded as having scent reads : " Resembling that of a twig of elder freshly broken."

In all cases the odour of *H. erato phyllis* was that of witch-hazel, similar to that of *H. erato hydarus*, Hew., in the Panama Canal Zone.

The age of the insects when caught, indicated by the degree of fading in the red band, affords no criterion as to the strength of the scent. Fresh and faded insects are present in each category, scent being present in a slightly higher proportion of the faded specimens.

It was noted that the scent did not appreciably increase if the butterfly was held in the fingers and allowed to struggle. When the cyanide bottle was opened after an insect had been imprisoned for some minutes, the odour was often very strong, seeming to indicate that the scent-glands had been brought into play.

At Urucum, some 250 to 300 miles south of the other localities, no *H. melpomene* were met with. In the remaining areas both species flew together, *H. erato* being always the more common.

From the table below it will be seen that 10·5 per cent. of the ♂♂ of *H. erato phyllis* are recorded as smelling, which increases to 65·1 per cent. in the ♀♀. For *H. melpomene burchelli* the single record of odour represents 2·56 per cent. of the ♂♂.

Two ♂ specimens of *H. erato* show " beak marks " on the wings, and although the butterfly has a somewhat leisurely flight, its power of dodging and acceleration on being alarmed are considerable. The fact that the odour is present in both sexes of the insect seems to indicate that it may have a protective value. The relative commonness of *H. erato* over *H. melpomene*, together with the scarcity of scent in the latter, supports the view of model and mimic suggested in Dr. Eltringham's paper on " Mimetic Relationships in the genus Heliconius," *Trans. Ent. Soc. London*, 1916, p. 101.

LIST SHOWING NUMBERS OF *HELICONIUS ERATO* AND *H. MELPOMENE* TAKEN IN LOCALITIES IN MATTO GROSSO, WITH PERCENTAGE OF SPECIMENS HAVING SCENT.

	Specimens taken.	Percentage.	Urucum.	Cuyaba.	Burity, 1st visit.	Burity, 2nd visit.	Tombador Sitio.	Tombador Falls.	Melguira.	Rio de Casca.
Heliconius erato phyllis.										
MALE.										
No scent . . .	102	89·5	6		43	5	25	1	21	1
Slight scent . . .	6	5·2	2			2	1		1	
Fairly strong scent . .	5	4·4	1		3				1	
Strong scent . . .	1	·9		1						
	114	100	9	1	46	7	26	1	23	1
FEMALE.										
No scent . . .	22	34·9	1	1	12		8			
Slight scent . . .	7	11·1	2		1	2	2			
Fairly strong scent . .	22	34·9			6	7	7		2	
Strong scent . . .	11	17·5	1	1	6		2		1	
Very strong scent . .	1	1·6			1					
	63	100	4	2	26	9	19		3	
Heliconius melpomene burchelli.										
MALE.										
No scent . . .	38				28	2	1	1	6	
Fairly strong scent . .	1				1					
	39				29	2	1	1	6	
FEMALE.										
No scent . . .	12				9		1		2	

4. SYSTEMATIC ACCOUNT OF THE BUTTERFLIES CONCERNED, TOGETHER WITH DESCRIPTIONS OF NEW FORMS.

By G. Talbot.

The butterflies here listed and described comprise only those dealt with in Mr. Collenette's paper. All types are in the collection of Mr. J. J. Joicey at the Hill Museum.

Family Pieridae.

1. *Dismorphia astynome*, Dalm. (1823). Plate XIV, figs. 1 and 2. 6 ♂♂, 3 ♀♀. A variable species. The yellow band on the fore-wing is generally broken, the apical spots are usually small and the upper one is sometimes absent. In a ♂ from Burity the apical spots are very large, the lower one a little larger than the discal spot in 2, but in this specimen the discal spots of the band are smaller than usual. In a ♂ from Rio Serragem the discal spots are very large and are joined to form a broad band which encloses a black discal spot. The two ♀♀ from Tombador Sitio also show a broad yellow band which is slightly narrower than in the ♂ from the Rio Serragem (1½ miles distant). The single ♀ from Burity agrees with 4 of the 5 ♂♂ from this place in having a broken band, but the spots are smaller.

Family Danaidae.

2. *Lycorea ceres atergatis*, D. & H. (1847). Plate XIV, fig. 3. 16 ♂♂, 8 ♀♀. The series is fairly constant and only in one specimen (Rio Serragem) is there a tendency for the spots in cellule 3 to become joined. The submarginal spot in 3 is variable with a tendency to reduction in size and in 2 from Serragem and 1 from Burity, this spot is entirely absent.

3. *Lycorea halia*, Hbn. (1816). Plate XIV, fig. 4. 1 ♂, 2 ♀♀. Also ab. *referrens*, Hnsch. (1909). Plate XIV, fig. 5. 1 ♂, 1 ♀. These are typical, with complete broad band on the fore-wing.

4. *Hirsutis pseudonyma pseudonyma*, Stgr. (1894). Plate XIV, fig. 6. 63 ♂♂, 33 ♀♀. The series is fairly typical except that in 5 ♂♂ and 1 ♀ the hind-wing shows a yellow discal band, and thus approaches the southern race *pseudethra*, Butl. (1873). The band of the fore-wing is variable and is rather broad in 31 specimens. The discal spots of the hind-wing vary in number. There is always a spot in cellule 4 and in 3, but others may be absent. In most specimens there are three spots, in others four, and in a few there are five spots in 4, 3, 2, 1*c*, 1*b*.

5. *Mechanitis polymnia*, L. **angustifascia,** subsp. nov. Plate XIV, fig. 7.

♂ ♀.—Partakes of the characters of the typical form and of *veritabilis*, Butl. (1873). The apical patch on the fore-wing is absent in some specimens, vestigial in the great majority, and distinct in a few, but never so marked as in some other races, thus resembling the typical form. Band of the fore-wing broader than in *veritabilis*, but narrower than in *polymnia* from the Lower Amazon. Black band of the hind-wing narrower than the width between its lower edge and the outer edge of the brown ground-colour in the great majority of specimens. In a few specimens there is an approach to the form *casabranca*, Hnsch. (1905), in the presence of a yellow anterior border to the discal band.

Underside of hind-wing with the black subcostal band very narrow, much less heavily marked than in the allied forms.

The antennae are, in the great majority, two-thirds yellow, but in some cases the yellow is reduced until in extremes only the club is coloured.

Hab.—Matto Grosso: Rio Serragem, 1500 feet, 20.viii.27 (♂ Type), 12.viii.27 (♀ Allotype), also 176 ♂♂, 95 ♀♀, 12–27.viii; Tombador Sitio, 1500 feet, 24.vii.–28.viii.27, 33 ♂♂, 25 ♀♀; Melguira, 2000 feet. 24.v.–3.vi.27, 3 ♂♂, 1 ♀; Burity, 2250 feet, 11.vi.–14.vii.27, 1 ♂, 2 ♀♀; Nobrés, 1250 feet, 21.v.27, 5 ♂♂, 1 ♀.

6. *Mechanitis elisa*, Guér., **connectens,** subsp. nov. Plate XIV, fig. 8.

♂ ♀.—The yellow discal spot in cellule 2 of the fore-wing is placed more proximal than in allied forms, and its anterior edge is produced proximally to touch the cell-spot or to become merged with it in some specimens. The form *elisa* occurs in only a few examples. In 13 specimens the yellow band is complete with, at the most, a minute black spot at the base of cellule 2; this extreme form is not taken as the type.

Hab.—Matto Grosso: Rio Serragem, 1500 feet, 12.viii.27 (♂ Holotype), 24.viii.27 (♀ Allotype), also 153 ♂♂, 58 ♀♀, 12.viii.–27.viii.27, also f. *elisa* 2 ♂♂, 14 ♀♀, and 1 ♀ approaching f. *ocona*, Druce (1876); Tombador Sitio, 1500 feet, 24.vii.–28.viii.27, 45 ♂♂, 26 ♀♀, also f. *elisa* 1 ♂, 3 ♀♀; Tombador Falls, 2000 feet, 8.viii.27, 1 ♀; Burity, 2250 feet, 3.vii.27, 1 ♀; Melguira, 2000 feet, 24.v.27, 1 ♀; Nobres, 1250 feet, 21.v.27, 2 ♂♂, 1 ♀, and f. *elisa* 1 ♀.

7. *Mechanitis lysimnia*, Fabr. (1793). Plate XIV, fig. 9. A single ♀ from Rio Serragem, 1500 feet, 18.viii.27.

8. *Ceratinia cantobrica pamina*, Hnsch. (1905). Plate XIV, fig. 10. 110 ♂♂, 197 ♀♀. The series is fairly constant. A few specimens have the posterior part of the yellow band separated from the anterior part, and some specimens have the black mark on the hind-wing absent.

9. *Ceratinia nina*, Hnsch., **chapadensis,** subsp. nov. Plate XIV, fig. 11.

♂ ♀.—Distinguished by the broader and more sharply defined yellow band on the fore-wing. The black border of the hind-wing is in most specimens broader than in the typical form.

Hab.—Matto Grosso: Burity, 2250 feet, 21.vi.27 (♂ Holotype), 18.vi.27 (♀ Allotype), also 31 ♂♂, 12 ♀♀, 11.vi.–14.vii.27, and 1 ♂, 13.ix.27.

10. *Sais rosalia*, Cram., **brasiliensis,** subsp. nov. Plate XIV, fig. 12.

♂ ♀.—Allied to *paraensis*, Hnsch. (1905). The yellow band of the fore-wing is narrower beyond the cell and is much narrower posteriorly. Hind-wing with reduced discal spots and no spot in cellule 2, or with this spot vestigial. Underside with reduced white dots and smaller black spots on the hind-wing.

Hab.—Matto Grosso: Rio Serragem, 1500 feet, 24.viii.27 (♂ Holotype), 25.viii.27 (♀ Allotype), also 5 ♂♂, 6 ♀♀, 12.viii.–27.viii.27; Tombador Sitio, 1500 feet, 24.vii.–28.viii.27, 8 ♂♂, 7 ♀♀; Tombador Falls, 2000 feet, 8.viii.27, 1 ♀; Burity, 2250 feet, 20.vi.27, 1 ♂; Melguira, 2000 feet, 2.vi.27, 1 ♂, 31.v.27, 1 ♀.

11. *Dircenna dero dero*, Hbn. (1823). Plate XV, fig. 9. 6 ♂♂, 6 ♀♀ from Burity, 2250 feet, 11.vi.–14.vii.27, and from Rio Serragem, 1500 feet, 12.viii.–27.viii.27.

12. *Dircenna zelie epidero*, Bates (1862). Plate XV, fig. 10. Burity, 2250 feet, 11.vi.–14.vii.27, 4 ♂♂, 3 ♀♀, 6.ix.27, 1 ♀; Rio Serragem, 1500 feet, 12.viii.27, 1 ♀. A variable form. The ♂♂ taken do not show a very marked transverse band on the hind-wing. The ♀♀ vary in the amount of black, and in the presence or absence of reddish-brown marks on the margins of the hind-wing and at the base of the fore-wing.

13. *Episcada clausina striposis*, Hnsch. (1909). Plate XV, fig. 1. 1 ♂, 18.vi.27 & 1 ♀, 20.vi.27, from Burity, 2250 feet.

There is a ♀ in the B.M. from Chapada, Matto Grosso.

14. *Episcada hymenaea hymenaea*, Prittw. (1865). Plate XV, fig. 2. Rio Serragem, 1500 feet, 18.viii.27, 1 ♂, 1 ♀.

15. *Aeria elodina*, Stgr. (1885). Plate XV, fig. 8. A single ♀ from Burity 2250 feet, 9.ix.27.

16. *Aeria olena*, Weym. (1875). Plate XV, fig. 7. A series of 101 ♂♂ & 51 ♀♀ from the Rio Serragem and Tombador Sitio. All varying greatly in size, but otherwise very constant.

17. *Hypoleria* **consimilis,** sp. nov. Plate XV, fig. 3.

♂ ♀.—Allied to *oreas*, Weym. (1899), and of about the same size. Fore-wing with broader black apex and strongly-marked white band reaching vein 5, the space between this and the black margin being much narrower than in *oreas*. The black half-band as in *oreas*, but with a tendency to be broader. Two whitish submarginal spots in 4 and 5, much larger than in *oreas*, a submarginal spot in 2 as in *oreas*, and a submarginal dot in 3. Hind-wing margins as in *oreas*.

Length of fore-wing—♂ 26 mm., ♀ 25 mm.

Hab.—Matto Grosso : Burity, 2250 feet, 13.vi.27 (♂ Holotype), 21.vi.27 (♀ Allotype), also 2 ♂♂, 12.vi.27, 1 ♂, 17.vi.27, 5 ♂♂, 18.vi.27, 1 ♂, 30.vi.27, 1 ♀, 12.ix.27. In the B.M. from Casabranca, S. Paulo, Brazil (1), and Chapada, Matto Grosso (7).

18. *Pseudoscada* **quadrifasciata,** sp. nov. Plate XV, fig. 4.

♂ ♀.—Allied to *utilla*, Hew. (1856). The white band of the fore-wing does not reach vein 5 and forms a large square patch, diffuse on its posterior edge, instead of a narrow band. The black discocellular band is broader than in *utilla*, and is not pointed. There is a small whitish spot in cellule 4 and four submarginal spots as in *utilla*. Abdomen below grey-white as in *utilla*.

Length of fore-wing—♂ 22·5 mm., ♀ 21 mm.

Hab.—Matto Grosso : Burity, 2250 feet, 18.vi.27 (♂ Holotype), 19.vi.27 (♀ Allotype), also 2 ♂♂, 1 ♀, 18.vi., 1 ♂, 21.vi.27, 1 ♀, 28.vi.27, 1 ♀, 30.vi.

19. *Pseudoscada arzalia*, Hew. (1876). Plate XV, fig. 5. 165 ♂♂, 182 ♀♀. This series is rather constant. The black apex of the fore-wing is a little broader than in Hewitson's figure, but agrees with the figure in Seitz (v. pl. 41*b*) with which the series also agrees in the size of the black half-band.

A specimen in the B.M. from Chapada, Matto Grosso, is also to be referred to the above.

20. *Pseudoscada* **collenettei,** sp. nov. Plate XIV, fig. 13.

♂ ♀.—This species is remarkable for its close resemblance to *Pteronymia antisao*, Bates (1862), and is so distinguished from any other species of *Pseudoscada*.

Allied to *salonina*, Hew. (1855), but differs abundantly in the yellowish-brown coloration of both wings due to the minute hairs which take the place of scales on the semi-hyaline area. Fore-wing with yellow post-discal band as in *salonina* and with a similarly shaped black-brown discal patch. Veins 2–4 striped with brown. A slight yellow stripe in cellule 2, accentuated at the margin, more prominent than in *salonina*. Hind-wing with the veins strongly yellow-brown.

Length of fore-wing—25·5 mm.

Hab.—Matto Grosso : Rio Serragem, 1500 feet, 16.viii.27 (♂ Holotype),

24.viii.27 (♀ Allotype), also 1 ♂, 18.viii.27, 1 ♀, 12.viii.; Tombador Sitio, 1500 feet, 29.vii.27, 1 ♀.

21. *Pseudoscada emyra*, Hnsch. (1905). Plate XV, fig. 6. 1 ♂ from Burity, 18.vi.27. A ♀ of this species is in the Hill Museum from Minas Geraes.

The ♂ above was taken in primeval forest flying with *P. arzalia*, which it very closely resembles. It differs from this species, however, not only by the pattern as described by Haensch, but also, to a very marked degree, in the genitalia.

22. *Heterosais edessa nephele*, Bates (1862). Plate XV, fig. 12. 39 ♂♂, 36 ♀♀ from Rio Serragem, 1500 feet, 12.viii.–27.viii.27, and Tombador Sitio, 1500 feet, 24.vii.–28.viii.27. The series is very constant.

Family Nymphalidae.

23. *Actinote pellenea calymma*, Jord. (1913). A single ♀ from Cuyaba, 13.v.27.

24. *Actinote parapheles parapheles*, Jord. (1913). 2 ♂♂, 5 ♀♀ from Burity, 11.vi.–14.vii.27.

25. *Heliconius numata metalilis*, Butl. (1873). Burity, 2250 feet, 21.vi.27, 1 ♂, 22.vi.27, 1 ♀, 3.vii.27, 1 ♀.

26. *Heliconius melpomene burchelli*, Poulton (1910). Plate XV, fig. 11.

Burity, 2250 feet, 29 ♂♂, 9 ♀♀, 11.vi.–14.vii.27, 2 ♂♂, 6.ix.–22.x.27; Tombador Sitio, 1 ♂, 1.viii.27, and 1 ♀, 6.vi.27; Tombador Falls, 1 ♂, 9.viii.27; Melguira, 6 ♂♂, 2 ♀♀, 24.v.–3.vi.27.

27. *Heliconius erato phyllis*, Fbr. (1775). 114 ♂♂, 63 ♀♀.

The red band is rather variable and is less sharply defined on its proximal edge in cases where it enters the cell. In some cases also the band is prolonged proximally at its lower edge to touch the yellow median stripe.

28. *Eueides vibilia unifasciatus*, Butl. (1873). 121 ♂♂, 35 ♀♀, from Cuyaba, 9.v.–19.v.27, together with f. *vibilia*, Godt. (1819), 9 ♂♂, 4 ♀♀; 9 ♂♂, 9 ♀♀ from Burity, 2250 feet, 11.vi.–14.vii.27, together with 2 ♂♂, 1 ♀ f. *vibilia*, Godt., 1 ♀ from the Rio Serragem, 1500 feet, 12.viii.–27.viii.27; 1 ♂, 1 ♀ from Tombador Falls, 2000 feet, 6 & 8.viii.27; 1 ♀ from Nobres, 21.v.27.

The form *unifasciatus* is not altogether stable as a few *vibilia* occur with it, besides some slight intermediates. The discal spots on the fore-wing of the ♂ are in some cases much paler than the other markings.

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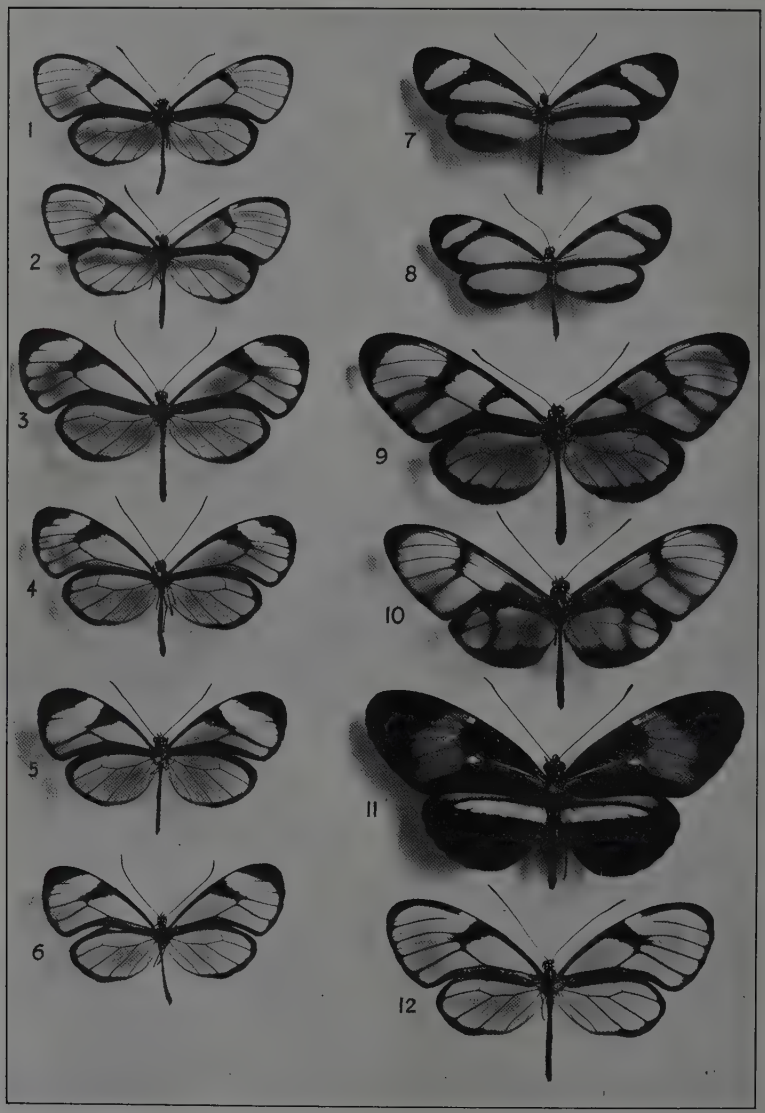
BUTTERFLIES OF MATTO GROSSO, BRAZIL.
MECHANITIS COMBINATION.



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BUTTERFLIES OF MATTO GROSSO, BRAZIL.

Explanation of Plates.

Plate XIV.

Mechanitis Combination.

Fig. 1. *Dismorphia astynome*, Dalm., ♂. Rio Serragem, August 25th, 1927.
2. *Dismorphia astynome*, Dalm., ♀. Tombador Sitio, August 15th, 1927.
3. *Lycorea ceres atergatis*, D. & H., ♂. Rio Serragem, August 14th, 1927.
4. *Lycorea halia*, Hbn., ♂. Burity, June 14th, 1927.
5. *Lycorea halia* ab. *referrens*, Hnsch., ♀. Burity, July 3rd, 1927.
6. *Hirsutis pseudonyma pseudonyma*, Stgr., ♀. Rio Serragem, August 16th, 1927.
7. *Mechanitis polymnia*, L., *angustifascia*, subsp. nov., ♂ Type. Rio Serragem, August 20th, 1927.
8. *Mechanitis elisa*, Guér., *connectens*, subsp. nov., ♂ Type. Rio Serragem, August 12th, 1927.
9. *Mechanitis lysimnia*, Fab., ♀. Rio Serragem, August 18th, 1927.
10. *Ceratinia cantobrica pamina*, Hnsch., ♀. Rio Serragem, August 12th, 1927.
11. *Ceratinia nina*, Hnsch., *chapadensis*, subsp. nov., ♂ Type. Burity, June 21st, 1927.
12. *Sais rosalia*, Cram., *brasiliensis*, subsp. nov., ♂ Type. Rio Serragem, August 24th, 1927.
13. *Pseudoscada collenettei*, sp. nov., ♂ Type. Rio Serragem, August 16th, 1927. Illustrated against a dark background.

Plate XV.

Fig. 1. *Episcada clausina striposis*, Hnsch., ♂. Burity, June 18th, 1927.
2. *Episcada hymenaea hymenaea*, Prittw., ♀. Rio Serragem, August 18th, 1927.
3. *Hypoleria consimilis*, sp. nov., ♂ Type. Burity, June 13th, 1927.
4. *Pseudoscada quadrifasciata* sp. nov., ♂ Type. Burity, June 18th, 1927.
5. *Pseudoscada arzalia*, Hew., ♀. Rio Serragem, August 16th, 1927.
6. *Pseudoscada emyra*, Hnsch., ♂. Burity, June 18th, 1927.
7. *Aeria olena*, Weym., ♂. Rio Serragem, August 25th, 1927.
8. *Aeria elodina*, Stgr., ♀. Burity, September 9th, 1927.
9. *Dircenna dero dero*, Hbn., ♂. Rio Serragem, August 14th, 1927.
10. *Dircenna zelie epidero*, Bates, ♂. Burity, June 30th, 1927.
11. *Heliconius melpomene burchelli*, Poulton, ♂. Burity, June 23rd, 1927.
12. *Heterosais edessa nephele*, Bates, ♂. Rio Serragem, August 14th, 1927.

Plate XVI.

Injuries probably inflicted by birds. Photograph taken by transmitted light.

Fig. 1. *Ceratinia cantobrica pamina*, ♀. Rio Serragem, August 12th, 1927. Beak mark on both fore-wings. The insect was captured when settled, or possibly with wings together in flight.

2. *Mechanitis elisa connectens*, ♂. Rio Serragem, August 18th, 1927. Beak mark on both fore-wings, continued on hind-wings. The impression is of a long, rather narrow beak, and the insect was captured when settled, or possibly with wings together in flight.

3. *Ceratinia cantobrica pamina*, ♂. Rio Serragem, August 16th, 1927. Beak mark on left fore-wing, and another on left hind-wing, probably made during one attack, by the same bird.

4. *Mechanitis polymnia angustifascia*, ♂. Rio Serragem, August 14th, 1927. Beak mark on right hind-wing, similar to that in Fig. 5.

5. *Mechanitis elisa connectens*, ♀. Rio Serragem, August 14th, 1927. Beak mark on left hind-wing. The insect was evidently seized from in front, and the injury to the corresponding fore-wing may have been caused by friction against the base of the bird's beak.

6. *Hirsutis pseudonyma pseudonyma*, ♂. Rio Serragem, August 20th, 1927. Two parallel beak marks on the left hind-wing, the inner one extending to the fore-wing. The outer marks probably show movement of the wing in an insecure grip.

7. *Mechanitis polymnia angustifascia*, ♂. Rio Serragem, August 12th, 1927. Beak mark on right hind-wing.

8. *Mechanitis elisa connectens*, ♂. Rio Serragem, August 12th, 1927. Marks on right fore-wing, continued in one case to the hind-wing, and perhaps made by the same bird. The two longer marks, however, may possibly be due to creasing of the wings in the net during capture. This type of injury is not common.

9. *Sais rosalia brasiliensis*, ♂. Rio Serragem, August 24th, 1927. Beak mark on left fore-wing, faintly duplicated nearer the outer margin.

Plate XVII.

A view in the Rio Serragem "oasis," looking towards the tributary shown in Plate XVIII. Imperial Eclipse plate. Stop f. 10. Exposure 2 seconds.

Plate XVIII.

Looking up the course of the tributary, Rio Serragem "oasis." Imperial Eclipse plate. Stop f. 10. Exposure ½ second.

Plate XIX.

Butterflies at damp sand. Including *Catopsilia statira* (the majority), *C. argante*, *C. philea*, *Papilio thyastes* (on right), *Megalura chiron* (on left), and *Libythea carinenta* (on extreme left). Burity, October 2nd, 1927.

Vaus & Crampton, Ltd.

INJURIES PROBABLY INFLICTED BY BIRDS. MECHANITIS COMBINATION.

Photo. C. L. Collenette. *Vaus & Crampton, Ltd.*

A VIEW IN THE RIO SERRAGEM "OASIS."

Photo. C. L. Collenette. *Vous & Crampton, Ltd.*

LOOKING UP THE COURSE OF THE TRIBUTARY, RIO SERRAGEM

Photo. C. L. Collenette. *Vans & Crampton, Ltd.*

BUTTERFLIES AT DAMP SAND.

HORAE FORMOSANAE

The Syntomidae of Formosa.

By A. E. Wileman.

(Late British Consul for the District of Tainan, Formosa, and late British Consul-General for the Philippine Islands.)

[Read June 6th, 1928.]

Plate XX.

Introduction.

Materials.—The materials referred to in the present survey of the Syntomidae of Formosa are to be found, for the most part, in the following museums and collections: British Museum (Natural History); Zoological Museum, Tring; Deutsche Entomologische Institut (Museum), Berlin-Dahlem; the Matsumura Collection in the Entomological Section of the Hokkaidō Imperial University, Sapporo, Japan; and the Wileman Collection.

Types of Syntomidae, which were described some years ago by Prof. Embrik Strand in the pages of the *Deutsche Entomologische Zeitschrift*, have been received on loan by Mr. W. H. T. Tams of the British Museum (Natural History) from Prof. Horn of the Deutsche Entomologische Institut (Museum), and have been placed at my disposal by Mr. Tams for examination. All these Strand types form part of the extensive collections of Lepidoptera, and of other orders of insects, made by Sauter in Formosa now deposited in various European museums. When all this material collected by Sauter, and also that of other collectors, is systematically and critically worked out it will very considerably enlarge our present knowledge of the Formosan insect-fauna and help to elucidate many zoogeographical problems of the distribution and inter-relation of Asiatic species, especially as regards Japan and the immense adjacent area of China.

Types have also been sent to me for comparison by Lord Rothschild, loaned from his lordship's magnificent and unique collections at the Zoological Museum, Tring, the descriptions of which have been published in the *Novitates Zoologicae*.

The descriptions of types contained in the Wileman Collection were published in the pages of the *Entomologist*, and the types themselves are contained in a collection of approximately some two thousand Formosan species (inclusive of Micro-lepidoptera) gathered together by the aid of native collectors and personal effort during a period of six years from 1903 to 1909, when I was stationed as British Consul in Formosa.

Analysis of Syntomidae.—So far as can be ascertained at present there are three genera, thirteen species and four subspecies of Syntomidae which occur in Formosa. Eight of these species seem to be peculiar to the Formosan fauna, as they are apparently not found in other countries. Three species occur in Formosa and other countries. Two species, *horishana* and *hoppo*, may be referable to two species already named and described which are found in China (East Central) and Nepal, India.

The four subspecies are :—

1. *Syntomis germana hirayamae*, Matsumura, closely allied to *Syntomis germana mandarinia*, Butler, from China (East Central) and Japan.
2. *Syntomis persimilis perixanthia*, Hampson.
3. *Syntomis dichotoma formosensis*, Wileman.
4. *Syntomis fortunei formosensis*, Wileman.

Citations and data concerning *Syntomis fortunei fortunei*, De l'Orza, are also given. This subspecies belongs to the fauna of Japan and is referable to the Palaearctic zone, not to the Indo-Australian zone in which Formosa is situated. Only two subspecies of SYNTOMIDAE occur in Japan, namely, *Syntomis germana mandarinia*, Butler, and *Syntomis fortunei fortunei*, De l'Orza, and, as these two have already been fully dealt with in the following pages, it is not deemed necessary to reserve them for future consideration in a paper exclusively devoted to a survey of the Japanese SYNTOMIDAE.

Citations.—The references to various authors and their publications which accompany each species are numbered in numerical rotation. The number attached to each citation is frequently employed in the text in brackets when it appears necessary to quote authorities or publications, or to explain facts concerning any author, publication or species connected with that special number. This system saves constant repetition in the text of the names of authors, publications and species, and at once aids reference to the original text.

Japanese Names.—The Japanese name of each species is, when known, placed after the Latin generic and specific names, and is followed by a number in brackets which refers to that particular publication in which the Japanese name concerned was first published by the author.

Japanese Localities.—The four principal islands of Dai Nihon, or Great Japan, known as Hokkaidō, Honshū, Shikoku and Kyūshū, are sometimes abbreviated to Hokk., Honsh., Shik., Kyū. In quoting localities situated in these islands the name of the island is given in small capitals, the name of the province in italics and the name of the town, or village, in ordinary type. In many instances the *Ken* (or Prefecture) has been added in bracketed italics after the name of the province, as for instance, thus :—KYŪSHU : *Hizen* (*Nagasaki*), Nagasaki.

Range.—The numbers placed in brackets after localities mentioned in the range of the species refer to the numbered citation which is the authority for the occurrence of a given species in that locality.

Types.—The sex and habitat of each type is given when known and also the museum or collection in which the type is at present deposited. In cases where these facts are not accurately known a sign of interrogation is prefixed.

Abbreviations.—

(0). = Sex not stated.
E. ed = English edition of Seitz's *Gross. Schmetterlinge der Erde*, i.e. *Macrolepidoptera of the World.*
E.T. = English text.
G.T. = German text.
J.T. = Japanese text.
J.E.T. = Japanese and English texts.
Nom. Jap. = *Nomen Japonicum*, also abbreviated sometimes as N.J.
Pf. = Plate, figure, *i.e.* Pf. 1.1 = Plate 1, figure 1.
Tf. = Text-figure.
U.M. Signifies under the microscope, or microscopic examination.

List of Formosan Localities mentioned in this Catalogue.

Alikang	=	Arikan	(C).	Kōshun			(S).
Ampin	=	*Anping*	(S).	Nanto			(C).
Anping	=	*Ampin*	(S).	*Polisha* recte *Polisia*	=	Horisha	(C).
Arikan	=	*Alikan*	(C).	*Polisia*	=	Horisha	(C).
Arisan	=	Arizan	(C).	*Pumpau*			(C).
Arizan	=	Arisan	(C).	Punkiko	=	Funkiko	(C).
Ban-kim-sing	=	Banshōryō	(S).	Punkio	=	Funkiko	(C).
Banshōryō	=	*Ban-kim-sing*	(S).	Sekijō			(?).
Chip Chip	=	Shūshū	(C).	Shabōsan			(?).
Funkiko	=	Punkiko, or Punkio	(C).	Shisa			(?).
Garambi			(S.)	Shūshū	=	*Chip Chip*	(C).
Hoozan	=	Hōzan	(S.)	Sokutsu			(S).
Hoppo			(C.)	Taihoku	=	*Taipeh*	(N).
Horisha	=	*Polisha* recte *Polisia*	(C).	Tainan			(S).
Hōzan	=	Hoozan	(S).	*Taipeh*	=	Taihoku	(N).
Kagi			(C).	*Takao*	=	*Takow*	(S).
Kankau			(S).	*Takow*	=	*Takao*	(S).
Kanshirei	=	*Koan-na-nia*	(C).	*Tamsui*	=	Tansui	(N).
Karapin			(C).	Tansui	=	*Tamsui*	(N).
Koan-na-nia	=	Kanshirei	(C).	Yama no Taiko			(?).
Kosempo			(S).				

N.B.—Names of localities in italics are the original Chinese or native names of those localities.

Names of localities in ordinary type represent the Japanese names for the original Chinese or native names, that is to say these Japanese names represent the Japanese pronunciation (not Chinese pronunciation) of the ideographs with which the Chinese or native names are written. For instance the ideographs for *Koan-na-nia* (Chinese) = the same ideographs for Kanshirei (Japanese). The geographical position of all localities named is indicated by (N), (S), (C), or where the position is unknown by (?).

Japanese Publications.—The full titles of certain Japanese publications referred to in an abbreviated form in this Catalogue are :—

1. Annotationes Zoologicae Japonenses. English text. Volume 16. 1907.

2. Catalogus Insectorum Japonicum. Volume 1; Nihon Konchū Sōmokuroku [J.E.T.], by Matsumura Shonen : A Catalogue of Japanese Insects. Lepidoptera only. Japanese and Romanised texts. Meiji 38 = 1905.

3. Journal of the College of Agriculture, Hokkaidō Imperial University, Sapporo, Japan. English text. Volume 19. 1927.

4. Nawa Yasushi Kanreki Kinen Kisō Rombunshū, edited by Nagano Kikujiro. Taisho 6 = 1917.

" A Collection of Essays for Mr. Yasushi Nawa. Written in Commemoration of his Sixtieth Birthday." English and Japanese texts.

5. Taiwan Sōtokufu Nōji Shikenjō, Shuppan Dai 68 go, VIII. Taisho 2 = 1913, by Shiraki Tokuichi.

Special Report of the Agricultural Experiment Station of the Government of Formosa. Researches concerning Common Insect Pests. Departmental No. 68. Volume 8. Japanese text with English translations of descriptions of new species.

N.B.—Following the Japanese custom the family name of authors is placed first and the year of the Japanese era corresponding to the year of the Western calendar is also given.

In concluding these prefatory explanations and remarks I must take this opportunity of expressing my grateful acknowledgments for the constant and

unfailing valuable advice, assistance and sympathy which I have received from Mr. W. H. T. Tams of the British Museum (Natural History) whilst I have been engaged in the preparation of this catalogue, and also for much aid and assistance received from Mr. R. J. West of the same Museum.

SYSTEMATIC INDEX.

[The bracketing of authors' names signifies change of genus.]

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SYNTOMIDAE.

SYNTOMIS.

Syntomis, Ochsenheimer, Eur. Schmett., 2, p. 103 (1808); Hampson, Cat. Lep. Phal., i, p. 59 (1898) (refer for all the synonyms of this genus).
Amata, Fabr., Illiger's Mag., 6, p. 289 (1807); Hampson, Cat. Lep. Phal. Suppl., i, p. 13 (1914), type *passalis* has priority.

Seitz, following Hampson, sinks *Syntomis* (1808) to *Amata* (1807), in *Gross. Schmett.* [E. ed.], Ind.-Aust., x, p. 67 (29.v.1912), but as *passalis*, Fabr., the type of *Amata*, has different neuration from that of *phegea*, Linnaeus (the type of *Syntomis*), in the present state of our knowledge the name of *Syntomis* may be retained.

1. **Syntomis alikangiensis,** Strand. (Plate XX, fig. 1.)

Nom. Jap. *Unnamed.*
1. *Syntomis muirheadi*, Feld., var. *alikangiensis*, Strand, Deutsch. Ent. Zeitschr., Berlin, 1915 H. i, p. 31, ♂ (1915) ♂, Formosa, Alikang.
2. *Amata takamukuana*, Matsumura, Journ. Coll. Agric. Sapporo (of Hokkaidō Univ.), 19, pt. 1, p. 74, pf. 4.13, ♂ (1927) ♂, Formosa.

Antennae:—Bipectinate, the rather curved pectinations of shaft delicately ciliate; *ex* male type *alikangiensis* (u.m.).

Strand says (1): "Two ♂♂ from Alikang, ix, lie before me which might be referred to this species" [*S. muirheadi*, Feld.], "at least they agree fairly

well with the form figured under this name in Seitz's work " [*Syntomis muirheadi*, Feld., Seitz in Seitz's *Gross. Schmett.* [E. ed.], Pal. 2, p. 40, pf. 9. g, (0) (1909)]. Seitz figures a specimen, sex ?, with simple antennae, and Strand does not diagnose the antennae of his variety *alikangiensis* in his description. I have examined Strand's male cotype and find that the antennae are very distinctly bipectinated and that *alikangiensis* is quite a separate species.

It may, apparently, be appropriately placed near, or after, *actaea*, Swinhoe [cf. Cat. Lep. Phal., i, pp. 62, 64] : " Antennae of male bipectinate, the branches rather short and dilated distally, of female serrate." Strand's type of *alikangiensis*, which is a fine, fresh specimen, certainly *does* superficially resemble a male specimen of *muirheadi* which is in the B.M. Coll. from " Ningpo VII, 1886, Leech Collection," China (E.C.) in the arrangement and number of the hyaline spots, but the antennae of this Ningpo male are white-tipped, serrated, with acuminate, ciliate teeth directed forward.

In *alikangiensis* :—

1. The body is shorter, less robust.

2. The expanse is narrower. *Muirheadi*, expanse 42 mm. (tip to tip 38 mm.); *alikangiensis*, expanse 36 mm. (tip to tip 33 mm.).

3. The black tooth projected up vein 2 from the black hind margin of hind-wing joins the cell, so that two hyaline spots are formed, which are separated by that vein from the large, single, inner, basal spot. This complete division of the hyaline spots of the hind-wing by vein 2 only occurs, as far as I am aware, in two Formosan Syntomids, viz. *nigrifrons* and *alikangiensis*, and in Chinese *persimilis persimilis*.

Strand remarks that " it appears rather questionable to me whether the form figured by Hampson as *S. muirheadi* is the same species." Hampson's figure, when compared with the other specimens in the series of *muirheadi* in the B.M. Coll., is evidently an aberration and should not have been selected for figuring as other specimens in this series seem to represent *muirheadi* better. (Cf. my remarks about *muirheadi*, p. 430.)

Amata takamukuana (2) is evidently referable to *alikangiensis* with which it agrees rather well. I have compared Matsumura's figure with Strand's type. The lower edge of the " long curved hyaline marking above vein 1," referred to by Matsumura in his description, is rather more concave in Strand's type than in the figure (2), but in all other respects they agree well. Matsumura never mentions the antennae which are prominently pectinated in Strand's type of *alikangiensis*. Perhaps the type of *takamukuana* may be a female, not a male, as there are no pectinations represented in the figure (2).

Range :—

B.M. Coll.
Wileman Coll. } No specimens from Formosa.

Deutsch. Ent. Inst. (Mus.). Berlin, " Sauter Ausbeute." } Formosa, 2 ♂♂ (type ♂), Alikang, ix.

Formosa only.

Regional range. Indo-Australian.

Types :—

Deutsch. Ent. Inst. Berlin, *alikangiensis*. ♂. Formosa, Alikang, ix.1909.

Hokkaidō Impl. Univ. Sapporo, *takamukuana*. ♂. Formosa, Horisha.

Expanse :—

♂ type, 36 mm. (tip to tip, 33 mm.).

♂ type, *takamukuana* 34 mm. (tip to tip, 32 mm.).

2. **Syntomis lucerna,** Wileman.

Nom. Jap. *Unnamed.*
1. *Syntomis lucerna,* Wileman, Entom., 43, p. 221, ♂♀ (1910) ♂♀, Formosa, Kanshirei.
2. *Amata lucerna,* Wilem., Hampson, Cat. Lep. Phal. Suppl., i, p. 34, No. 140*a*, pf. 2.24, ♂ (1914).
3. *Syntomis lucerna,* Wilem., Seitz in Seitz's Gross. Schmett. [E. ed.] Ind.-Aust., 10, p. 79 (1913).

Antennae :—Male type. White-tipped, minutely ciliate (mildewed).

Female. White-tipped, minutely ciliate, setae double the length of cilia but increasing in length towards apex; "Kanshirei, 9.v.1908," *ex* B.M. Coll. (u.m.).

The male and female types of *lucerna* were captured *in copulâ* at an altitude of 3,200 ft., near Kanshirei, Formosa. Hampson places *lucerna* after *germana,* Herrich-Schäffer (2, p. 78); and *flava,* which I described as a subspecies of *lucerna,* he places after *pfeifferae,* Moore (2, p. 30, Suppl.). Shiraki refers to *lucerna* as a synonym of *perixanthia,* Hmpsn. (cf. p. 433).

Range :—
B.M. Coll. Formosa. 3 sps. 1♂, 2 ♀♀.
Kanshirei (v, Wileman); Polisia (iii, Sauter).
Wileman Coll. Formosa. 2 sps., 1 ♂, 1 ♀ (types).
Kanshirei (v, 1,000 ft.).
Formosa only.
Regional range. Indo-Australian.
Type :—
Wileman Coll. *lucerna.* ♂♀. Formosa, Kanshirei.
Time of Appearance :—iii, v.
Expanse :—
♂, 36 mm.–46 mm. (tip to tip, 34 mm.–43 mm.).
♀, 42 mm.–50 mm. (tip to tip, 39 mm.–45 mm.).

3. **Syntomis flava,** Wileman.

Nom. Jap. *Unnamed.*
1. *Syntomis lucerna flava,* Wilem., Wileman, Entom., 43, p. 221, ♂ (1910) ♂, Formosa, Banshōryō.
2. *Amata aurantiifrons,* Rothschild, Nov. Zool., 18, p. 154, ♂ (1911) ♂, Formosa, Tainan.
3. *Amata aurantiifrons,* Rothschild, Nov. Zool., 19, p. 377, pf. 5.14, ♂ (1912).
4. *Amata aurantiifrons,* Rothsch., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 77 (1913).
5. *Syntomis lucerna flava,* Wilem., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 79 (1913).
6. *Amata flava,* Wilem., Hampson, Cat. Lep. Phal. Suppl., i, p. 30, No. 128*b*, pf. 2.19, ♂ (1914).
7. *Amata aurantiifrons,* Rothsch., Hampson, Cat. Lep. Phal. Suppl., i, p. 30 (1914).

Antennae :—White-tipped, minutely ciliate, setae double the length of cilia but increasing in length towards apex; *ex* male type *aurantiifrons,* the antennae of male type *flava* are mildewed (u.m.).

I described *lucerna flava* as a subspecies of *lucerna,* Wilem. (1), but Hampson separates them (6). I am inclined to think, however, that *flava* is merely a colour-variation of *lucerna,* possibly a seasonal form, but keep it separated provisionally.

I have examined the type of *aurantiifrons* (2) which Lord Rothschild has kindly lent me for examination, and have come to the conclusion that it should be sunk to *flava* as an aberration. It differs from the male type of *flava* and the female in the Wileman collection in the fact that the "quadrate subbasal spot below the cell" and the "oblique patch below vein 2" of upper wing (6) are confluent, thus making one spot on the left fore-wing and *almost* one spot on the right fore-wing.

Range :—

B.M. Coll. Formosa. No specimens. Coloured figures of type and of *aurantiifrons.*

Wileman Coll. Formosa. 1 ♂ (type), Banshōryō (ix, Wileman), 1 ♀ Kōshun (ii, Moltrecht).

Formosa only.

Regional range. Indo-Australian.

Types :—

Wileman Coll. *flava.* ♂. Formosa, Banshōryō.

Tring Mus. *aurantiifrons.* ♂. Formosa, Tainan.

Time of Appearance :—ii, ix.

Expanse :—

♂, 42 mm. (tip to tip, 38 mm.).

♀, 44 mm. (tip to tip, 40 mm.).

Syntomis germana, Felder. (Plate XX, fig. 2.)

4. **Syntomis germana hirayamae** (*Matsumura*), subspecies.

(Plate XX, figs. 17, ♂, 18, ♀.)

Nom. Jap. *Kihada-Kanoko* (11).

1. *Syntomis fenestrata,* Drury, Herrich-Schäffer (*error determinationis,* nec *S. fenestrata,* Drury), Aussereurop. Schmett., p. 72, f. 270, (0) (1855), China.
2. *Syntomis germana,* Felder, Wien. Ent. Mon., 6, p. 37, ♂ (1862) ♂, China, Ningpo (E.C.).
3. *Syntomis thelebus,* Fabr., Ménétries (*error determinationis,* nec *S. thelebus,* Fabr.), Schrenck's Reisen Amurld, 2, Lep., p. 48 (1859), East Siberia, Amurland, Ussuri.
4. *Syntomis mandarinia,* Btlr., Butler, Journ. Linn. Soc. Zool., 12, p. 349, (0) (1876) ♀, China, Shanghai (E.C.).
5. *Syntomis thelebris* (*sic*), Fabr., Pryer (*error determinationis,* nec *S. thelebus,* Fabr.), Trans. Asiatic Soc. Jap., 12 (2), p. 43, No. 78 (May, 1884).
6. *Syntomis thelebus,* Fabr., Leech (*error determinationis,* nec *S. thelebus,* Fabr.), Proc. Zool. Soc. Lond., p. 593 (1888).
7. *Syntomis germana,* Feld., Hampson, Cat. Lep. Phal., i, pp. 78, 93 (1898).
8. *Syntomis thelebus,* Fabr., Staudinger (*error determinationis,* nec *S. thelebus,* Fabr.), Mém. Lép. Rom., 6, p. 252 (1892), East Siberia, Amurland, Ussuri.
9. *Syntomis thelebus,* Fabr., Leech (*error determinationis,* nec *S. thelebus,* Fabr.), Trans. Ent. Soc. Lond., p. 320 (1898).
10. *Syntomis germana,* Feld., Staudinger-Rebel, Cat. Lep. Pal., i, p. 363, No. 4154 (1901).
11. *Syntomis germana,* Feld., Matsumura, Cat. Ins. Jap. (Nihon Konchū Sōmokuroku [J.E.T.], i, p. 170, No. 1438 (18.viii.1905) N.J. *Kihada-Kanoko.*
12. *Syntomis germana,* Feld., var. *nigricauda,* Miyake (T.), Annot. Zool. Jap. [G.T.], 6 (3), p. 161, ♂ (1907) ♂, Japan, Chikatsuyu.
13. *Syntomis germana,* Feld., Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 40, pf. 9. g. (0) (1909).
14. *Syntomis germana,* f. *mandarinia,* Btlr., Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 40, pf. 9. h. (0) (1909).
15. *Syntomis germana,* Feld., Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]), Suppl. 3, p. 55, No. 592, pf. 34.12, ♀ (1911), N.J., *Kihada-Kanoko.*
16. *Syntomis germana,* Feld., Zerny in Junk's Lep. Cat., 7, pp. 16, 22 (25.vii.1912).
17. *Syntomis germana,* Feld., Strand, Deutsch. Ent. Zeitschr., Berlin, **1915,** p. 32 (1915) = ? *hirayamae,* Mats.
18. *Amata takanonis,* Matsumura, Journ. Coll. Agric. Sapporo (of Hokkaidō Univ.) [E.T.], 19, pt. 1, p. 74, pf. 4.12, ♂ (1927) ♂, Japan, Honshū I. = *germana mandarinia,* ab.
19. *Amata hirayamae,* Matsumura, Journ. Coll. Agric. Sapporo (of Hokkaidō Univ.) [E.T.], 19, pt. 1, p. 74, pf. 4.14, ♀ (1927) ♀, Formosa, Tainan = subsp. of *germana.*
20. *Amata genzana,* Matsumura, Journ. Coll. Agric. Sapporo (of Hokkaidō Univ.) [E.T.], 19, pt. 1, p. 75, pf. 4.10, ♀ (1927) ♀, Genzan, Korea = ? var., ? or subsp. of *germana.*

Antennae :—

S. germana mandarinia. Male. Apical one-fourth white-tipped, minutely ciliate, setae double the length of cilia. Not simple as in Hampson (7, p. 76); *ex* male, " Asama Yama, prov. Shinano, Honshū, Japan, viii.1894," *ex* Coll. Wileman.

Female type *mandarinia*. Incomplete. Minutely ciliate, setae double the length of cilia; *ex* "Shanghai, China (E.C.)," *ex* B.M. Coll.

Female. Apical one-fourth white-tipped, minutely ciliate, setae double the length of cilia; internal edge of shaft with paired setae at each joint; *ex* female, "Tsuruga, Japan, July," *ex* B.M. Coll.

S. germana hirayamae. Male. Apical one-fifth white-tipped, minutely ciliate, setae double the length of cilia; *ex* "Kanshirei, Formosa, 21.iv.1906," *ex* Wileman Coll.

Female. Similar to male *hirayamae*. Internal edge of shaft, apparently with (?) single setae at each joint; *ex* "Kanshirei, Formosa, 21.iv.1905," and "Garambi, 3.x.1904," *ex* Wileman Coll. (mildewed). (All u.m.)

A test of sex in *germana mandarinia* and *germana hirayamae* seems to be that in the male the ninth abdominal segment and anal tuft are blacker and more definitely marked than in the female.

Seitz (13) states that "probably *polymita*, Sparrm. (= *thelebus*, F.), from South China is only a Southern representative of this East Asiatic species" [*S. germana*, Feld.]. Hampson also separates the two species (7, p. 92) and records *polymita* from Hongkong, and there is a series of seven specimens from Hongkong in the B.M. Coll. which forms part of Hampson's record. It is interesting to note that Sparrman's type of *polymita* was taken at Nord Eyland [North Island], Sumatra, so this extends the range of *polymita* further south than Hainan or Tonkin, which seems to be its present southern limit. The citation for *polymita* is Sparrman in Linn. Amoen. Acad., 7, pp. 503, 504, note p. (1769). In the Latin text of those days he says: "Febr. 9 [1767], *ad Insulam Nord Eyland anchora tenebamur, ubi sequentia occurebant*" (Sparrm., *l.c.*, p. 503). Amongst "*sequentia*" was the type of *Sphinx polymita* (note p. *l.c.*). Nord Eyland figures as Noorder Eylandt on the old Dutch chart shown to me at the Department of Maps, British Museum, and is named on the Admiralty Chart of the Sunda Straits, of 1868, as North Island, situated at the almost extreme south-eastern point of Sumatra before one enters the Straits of Sunda, to the North of Seven Sisters Island and Zutphen Island. On the old Dutch chart "Eylandt" is written "Eyt," the crossed "l" being apparently an abbreviation for "andt." Pryer (5) records *thelebris*, Fabr., error for *thelebus*, Fabr. (nec *thelebus*, Fabr.), from Ōyama, Fujisan, and also Kanōsan [Honshū I., Kazusa (Chiba Pref.)], all in Japan, "always at about 1,000 ft. elevation." He says it "varies greatly in size." These specimens are no doubt referable to *germana mandarinia*, Btlr. I do not, however, find any of them in the B.M. Coll., where one would expect to find them, as Pryer's collection was incorporated in the Leech collection which was subsequently bequeathed to the British Museum. Leech (6), in his *Lepidoptera of Japan and Corea*, says: "I got a nice series of this species in Japan and Corea [*S. thelebus*] showing considerable variation in size and number of hyaline spots; but in Pryer's collection there was a series which had evidently been made up of specimens selected to show something of the entire range of macular aberration in Japanese *S. thelebus*. At one end of this series is a specimen minus the apical spot, and the other spots on primaries are very small, whilst at the other end is an example which has exceedingly large spots, and in consequence might be said to have hyaline primaries with black transverse and longitudinal band-like markings; between these two are all the intermediate gradations, some of which have the basal spots of all the wings thinly clothed with yellowish scales. In the series I obtained are specimens with an extra hyaline spot above or below the usual apical one, and others which have both these additional spots.

" Expanse 30–40 millim.

" Oiwake, Ohoyama, Fujisan, Kanōsan (Pryer); Nagahama, Nagasaki, Tsuruga, Gensan (Leech); Ningpo, Corea (Herz); Kiukiang (Pratt); Amur."

None of these specimens referred to by Leech (with the exceptions noted below) is to be found in the B.M. Coll., where they ought to be if all of them had been retained instead of being probably distributed to various collections in England. The exceptions are one specimen each from Tsuruga and Nagasaki in Japan and Gensan, Korea. This male from Gensan, Korea, is noteworthy for very much resembling *polymita*, Sparrm., in that it has orange frons, patagia, tegulae, meso- and meta-thorax, but has the expanse, shape and markings of *mandarinia*.

Hirayamae (19) *seems* to be a subspecies of *germana* and a connecting-link between *mandarinia* in Japan and *polymita* in Hongkong. Matsumura's figure of *hirayamae* does not agree with his English description. In the description he says : " Abdomen with each a black band on the 1st, 6th and 7th segments." In the figure, however, there are seven black bands (inclusive of the basal band beneath metathorax). I base therefore my conclusions on the figure. I have a female from " Garambi, Formosa, 3.x.1904," which evidently represents the figure, and there are in the B.M. and Wileman Collections a series of three males and three females from Formosa which are undoubtedly referable to this Garambi specimen. They differ a little *inter se*. Three have the minute, apical, hyaline spot of the post medial series of upper wing, two have not, this difference is not sexual. The sixth specimen is an aberration, or teratological specimen. The right upper wing is minus vein 7, and the minute spot is missing. The left wing has the spot, and vein 7 is present, dividing the spot from the lower one of the series.

The male type of *germana*, Feld., is not available for examination and is probably lost, but Lord Rothschild has kindly lent me a female from the Tring Museum which is labelled " *Amata germana*, Felder Coll." I understand that this is the female type of *germana*, but it is not so labelled. Felder says nothing about a female in his original Latin description of the male which comes from Ningpo, China (E.C.). This female is very small, and agrees in expanse with three similar specimens from the Chusan Islands, China (E.) and one from Chungking, China (E.) in the B.M. Coll. In expanse it measures 28 mm. (tip to tip 27 mm.) whilst a large female *mandarinia* from Japan " Tsuruga, Leech " *ex* B.M. Coll., measures, expanse 42 mm. (tip to tip 38 mm.).

On comparing the series of Formosan *germana hirayamae* with those of Japanese *germana mandarinia* the following differences are apparent :—

1. In Japanese *mandarinia* the outer margin of hind-wing is more broadly black (especially at apex) than in *hirayamae*.

2. The triangular tooth running up vein 2 from the hind margin of lower wing is well developed in *hirayamae* and sometimes extends half-way up the vein towards cell. In *mandarinia* from Japan this tooth is sometimes absent, or not very much developed, but more so in Chinese specimens of *mandarinia*.

3. The antennae of male *hirayamae* and of male *mandarinia* seem to be the same under the microscope. Matsumura compares *hirayamae* with *lucerna*, Wilem. *Lucerna* certainly resembles *hirayamae* in the arrangement and number of hyaline spots, but not in expanse. In expanse it measures, male, 36 to 46 mm., female, 42 to 50 mm., whilst *hirayamae* expands, male, 30 to 32 mm., female, 30 to 32 mm. Sometimes, as in *germana mandarinia*, the minute, apical, hyaline spot of the post-medial series is absent; it is present in one male and two females and absent in two males and one female.

I have examined a series of forty-nine males and females of *germana* in the B.M. and Wileman Collections, mostly consisting of *germana mandarinia*, of which twenty males and females are referable to Japanese *mandarinia*. Amongst the Japanese series I have found a female from "Japan, Strickland, 1910," which closly resembles *takanonis* (18). There is also a somewhat similar specimen from "Foochow, April 1886, Leech," China (E.). Both these are in the B.M. Coll. The female from Japan is minus the apical, hyaline spot of *takanonis*, but, in other respects, matches very well with it, therefore *takanonis* should, I think, be regarded as an aberration of *germana mandarinia*. (Cf. Leech's remarks quoted on p. 424.)

Shiraki states (*in litt.*) that the larva of *Amata mandarinia* feeds, in Formosa, on *Mikan* (Orange-tree, *Citrus* sp.); probably this is *S. germana hirayamae*. Strand also records *germana* (17) from Formosa, and compares three specimens from Yama no Taiko with the figure of Seitz (13, pf. 9. g. (0)). This plate-figure represents *germana* but is not mentioned in the text. It seems to represent *mandarinia*, Btlr., not *germana*, and it agrees well with Butler's female type, much better than with *germana*, Feld., female type. Strand's specimens are probably *germana hirayamae*. He says that Formosan *germana* is easily distinguishable from *S. polymita*, Sparrm., by the absence of the long, yellow streak on both margins of the fore-wing, and also of the yellow collar and yellow patagia (my tegulae). These are the characters of the series of eleven *polymita* in the B.M. Coll. from Hongkong, Tonkin, Hainan and China (W.). In expanse Formosan *germana* comes nearer to the female type *germana* ex Coll. Rothschild, Tring Museum, than to any others in the series of *germana* in the B.M. and Wileman Collections. The male type of *germana* was described from Ningpo, China (E.C.), and possibly the female type, which assimilates in expanse with Chusan Islands specimens, comes from the same locality as the male.

A perusal of Strand's remarks (17) on Formosan *germana* tend to confirm me still more in my belief that Matsumura's *hirayamae* should rank as a subspecies of *germana*, as these remarks seem quite applicable to *hirayamae*.

Matsumura, in his description of *genzana* (20), says that it is "closely allied to *A. perixanthia*, Hamps." It seems, however, to be much nearer *S. germana*, Feld., and is most probably a form of that species, in which case it would rank merely as an aberration, or variety, or, if the characters special to it were constant in a series, as the Korean subspecies.

Amongst the forty-nine specimens of *germana* already referred to, I find one female from "Kiukiang, June, 1887, A. E. Pratt," China (C.), in which the expanse 39 mm. (tip to tip, 36 mm.) and the hyaline spots, resemble Matsumura's figure (20), and in several cases the abdomen of *germana* is a very light yellow as in *genzana*, the black abdominal bands being more or less obsolescent. In *germana*, however, the frons and patagia (collar) are yellow, the tegulae black, which does not agree with the "greyish testaceous patagia" of *genzana*. Nothing in the description is said about the frons, tegulae, or antennae and it is not sufficient to form a decided opinion from one specimen only. In any case, however, *genzana*, is much nearer *germana* than *perixanthia*, with which Matsumura compares it. (Cf. Leech's remarks, *antea*.)

Range of S. germana mandarinia :—

B.M. Coll. Japan. 8 sps. 2 ♂♂, 6 ♀♀.

Honshū :	*Musashi*, Tōkyō;
	Echizen (*Fukui*), Tsuruga, vii.
Kyūshū :	*Hizen* (*Nagasaki*), Nagasaki, vi.

Wileman Coll. Japan. 4 ♂♂, 10 ♀♀.
Honshū : *Sagami*, Ōyama, 12 sps., vi, 1,000–2,000 ft.;
Settsu (*Hyōgo*) Kōbe, 1 sp., vi;
Shinano, Asama Yama, 1 sp., viii.

Range of S. germana hirayamae :—
B.M. Coll. Formosa. 1 sp. ♂.
Polisia (Horisha), iii, Sauter.
Wileman Coll. Formosa. 5 sps. 2 ♂♂, 3 ♀♀.
Garambi, x; Kanshirei, iv.
Deutsch. Ent. Inst. (Mus.). Berlin, " Sauter Ausbeute."
Formosa. 22 sps.
Sokutsu, vi; Chip-chip, ii; Kanshirei, v; Yama no Taiko, x; Kankau (Kōshun), iv, v, vi; " Shisa," v–vi; Alikang, x; Tainan, ii; (under *germana*).

General Range of S. germana :—
Japan; Korea; China, N., E., W., S., Cent., min. alt., Chia-ting-fu, 1,000 ft., max. alt., Huang-mu-chang, 7,000 ft.; Chusan Is.; Formosa; Hainan (B.M., Strand, Wileman); Japan (Honshū, Shikoku, Kyūshū) (Matsumura, Wileman); East Siberia (Amurland, Ussuri).

Time of Appearance :—
Japan : vi, vii, viii. Formosa : ii to vi and x.

Types :—

B.M. Coll.	*mandarinia.*	♀.	China (E.C.), Shanghai.
Tring. Mus.	*germana.*	♀.	China (E.), ? Ningpo.
?Science College, Tōkyō.	*nigricauda.*	♂.	Japan [Honshū I.], *Kii*, (*Wakayama*) Chikatsuyu.
Hokkaidō Impl. Univ. Sapporo	*takanonis.*	♂.	Japan, Honshū I.
	hirayamae.	♀.	Formosa, Tainan.
	genzana.	♀.	Korea, Genzan.

Expanse :—
S. germana mandarinia. " 30–40 mm. Leech " (6).
S. germana hirayamae. 28–34 (tip to tip, 26–30 mm.).

5. **Syntomis karapinensis,** Strand. (Plate. XX, fig. 3.)

Nom. Jap. *Unnamed.*
1. *Syntomis karapinensis*, Strand, Deutsch. Ent. Zeitschr., **1915**, H. i, p. 34, ♂ (1915) ♂, Japan ! Karapin (Formosa, *nec* Japan).
2. *Syntomis karapinensis*, Strand, Bang-Haas, Novit. Macrolep., p. 113 (1926), Japan !

Antennae :—Male type. Minutely ciliate, setae about same length as cilia, but longer towards apex.

I have examined the male type of *karapinensis*, which Strand compares with *S. newara*, Moore. The antennae of male *karapinensis* (under the microscope) are minutely ciliate, those of *newara* male are minutely serrate, the serrations curved forward and ciliate (serrate-ciliate); of *newara* female, somewhat similar with longer setae (serrate-setose). *Karapinensis* is referred by Strand to Group C (Syntomis) b^1, in Cat. Lep. Phal., i, pp. 76–78 (1898), " with antennae simple in both sexes."

This species, a very striking Formosan Syntomid, was never captured by my collector, or by myself, during the whole of the six years I was stationed in Formosa. Strand (1) makes a mistake in giving the locality of this species as " Karapin, Japan "; it should read Karapin, Formosa. Karapin is a Formosan

name, *not* a Japanese name, and is situated at about three thousand feet altitude on the route to Pumpau. Arizan Range, Formosa. I have collected there on my way to Pumpau. No doubt the wrong labelling of Sauter's original locality-envelopes is responsible for this mistake. *Karapinensis*, therefore, cannot be regarded as a Japanese species as mentioned (in 1 and 2).

Range :—

B.M. Coll. } No specimens from Formosa.
Wileman Coll. }
Deutsch. Ent. Inst. (Mus.), Berlin, "Sauter Ausbeute." } Japan ! (Formosa) male type, viii.1911.

Formosa only.
Regional range. Indo-Australian.

Type :—

Deutsch. Ent. Inst. (Mus.), Berlin. *karapinensis*. ♂. Japan ! (Formosa *nec* Japan) Karapin.

Expanse :—

"Length of fore-wing, 16·5 mm." (Strand).
Expanse 36 mm. (tip to tip, 33 mm.) (Wileman).

6. **Syntomis wilemani** (Rothschild).

Nom. Jap. *Unnamed.*

1. *Amata wilemani*, Rothschild, Nov. Zool., 18, p. 154, ♂ (1911) ♂. Formosa, Tainan.
2. *Amata wilemani*, Rothschild, Nov. Zool., 19, p. 377, pf. 5.21, ♂ (1912).
3. *Syntomis wilemani*, Rothsch., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 71 (1913).
4. *Amata vilemani* (!), Rothsch., Hampson, Cat. Lep. Phal. Suppl., i, p. 35, No. 150a (1914).
5. *Syntomis punkikonis*, Strand, Deutsch. Ent. Zeitschr., Berlin, **1915**, H. i, p. 33, ♀ (1915) ♀, Japan ! Punkiko (Formosa *nec* Japan).
6. *Syntomis wilemani*, Rothsch., Strand, Deutsch. Ent. Zeitschr., Berlin, **1915**, H. i, p. 33 (1915).

Antennae :—Male type. White-tipped, minutely ciliate, setae double and triple the length of cilia and increasing in length towards apex (u.m.).

I have compared the male type of *wilemani* (1) with the written description of Strand's female *punkikonis* (5), and have come to the conclusion that *punkikonis* (which Strand named provisionally, on the assumption that it might not be identical with *S. wilemani*) is not a separate species. The female does not differ from the male very much, the chief difference consisting in the cream-white scaling of the submarginal interspaces between the veins of the fore-wing. Strand, as I have already pointed out in the instance of Karapin (cf. p. 427), is mistaken in localising the female from Punkiko, *Japan*. Punkiko (pronounced also Punkio and Funkiko) is *not* situated in *Japan* but in *Formosa*, and is passed on the route from Kagi to Pumpau, Arizan Range.

Range :—

B.M. Coll. } No specimens from Formosa, but there is a
Wileman Coll. } coloured drawing of the male type in B.M. Coll.
Deutsch. Ent. Inst. (Mus.) Berlin. "Sauter Ausbeute." } Japan ! ♀. Punkiko, viii.1911 (*punkikonis*) (Formosa *nec* Japan).

Formosa only.
Regional range. Indo-Australian.

Types :—

Deutsch. Ent. Inst. (Mus.). *punkikonis.* ♀. Provisional name; type *not* marked in D.E.I. Berlin. Formosa, Punkiko.

Tring Mus. *wilemani.* ♂. Formosa, Tainan.

Time of Appearance :—viii.

Expanse :—

" Length of fore-wing, 24 mm." (Rothschild).

Expanse. 44 mm. (tip to tip, 42 mm.) (Wileman).

7. **Syntomis horishana,** Matsumura.

Nom. Jap. *Horisha-Kanoko.*

Syntomis horishana, Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.E.T.]) Suppl., 3, pp. 68, 69, No. 615, pf. 35.19, ♀ (1911) ♀, Formosa, Horisha. N.J. *Horisha-Kanoko.*

Antennae :—Unknown.

I think that Matsumura's two species, *Syntomis horishana* and *Syntomis hoppo*, are probably forms of the same species and that they are possibly referable either to *Syntomis muirheadi*, Feld. (Plate XX, fig. 11, ♀), from China (E.C.), or to *Syntomis melas*, Wlk. (Plate XX, fig. 12, ♀), from Nepal, India (= *melaena*, Hmpsn. *nec* Wlk., new name without reason, Cat. Lep. Phal., i, p. 96, No. 150 (1898)). The figures of *horishana* and *hoppo* and their short descriptions, given both in Japanese and English, are not sufficient to enable me to determine them with accuracy, so I leave them under their present names until further information and material are available. Matsumura does not say anything about the antennae, which would have been a help in determination. It is quite possible that they are both referable to *muirheadi*, Feld. (Plate XX, fig. 11, ♀), as this species occurs in Hongkong, latitude 22° 12′ N., to the south of the most southern point of Formosa, which is about 23° N. If one considers the two figures of *horishana* and *hoppo* as those of a male and a female instead of as those of two females, as recorded in the plate-index, they would, provided that they were accurately drawn according to the measurements of the text-expanses, be nearer *muirheadi* (Plate XX, fig, 11) than *melas* (Plate XX, fig. 12).

There is one male specimen of *muirheadi*, Feld., from " Hongkong (Bowring) " in the B.M. Coll. which seems to resemble Matsumura's female figure of *horishana.* It has seven abdominal, orange bands, the frons, patagia (collar), tegulae, meso- and meta-thorax are orange and the anal segment is orange with a black tip. The curved, hyaline, basal streak enclosed by the median nervure and vein 2 is longer, narrower, and slightly more curved, but the hyaline spots are rather smaller than in figure. The antennae are missing in the Hongkong specimen, but as Matsumura does not mention these no comparison could be made.

Antennae of male muirheadi :—Apical one-fourth white-tipped, serrated, with acuminate, ciliate teeth directed forward; *ex* Hongkong male figured by Hampson (Cat. Lep. Phal., i, p. 95, pf. 3.13, ♂, China, Hongkong) (u.m.), *ex* B.M. Coll.

Antennae of female muirheadi :—Apical one-third white-tipped, minutely dentate-ciliate-setose, *ex* female " Kiukiang, June, 1887, A. E. Pratt " (u.m.) *ex* B.M. Coll.

Expanse, 48 mm. (tip to tip, 43 mm.). *ex* Hongkong male.

Matsumura's figure of *horishana.* Expanse, 56 mm. (tip to tip 52 mm., *circa*). In the text Matsumura states that *horishana* expands 48 mm., which does not agree with the measurements of his figure.

The female type of *melas*, Wlk., in B.M. Coll. from Nepal, India, seems to resemble Matsumura's figure of *hoppo*. It has five black and six lemon-coloured abdominal bands; the frons, patagia (collar), tegulae, meso- and meta-thorax are whitish-lemon colour, the two anal segments are black shot with purple; expanse, 60 mm. (tip to tip 52 mm.); antennae, apical two-thirds white-tipped, minutely dentate-ciliate-setose, *ex* female, "Darjiling, 79–56," B.M. Coll. (u.m.).

In the text Matsumura states (*horishana*, pp. 69, 70, *l.c.*) that *hoppo* expands 48 mm., but this does not agree with the measurements of his figure, expanse, 56 mm. (tip to tip 53 mm., *circa*). It is possible that a mistake has been made in the sex of *horishana* and that the female sign ought to be read as male, both in plate and text. I have compared Matsumura's figures with sixteen male and female specimens of *muirheadi* and ten males and females of *melas*. Expanses of both are as follows :—

S. muirheadi.

Smallest male. Expanse, 40 mm. (tip to tip, 36 mm.).
Largest female. Expanse, 52 mm. (tip to tip, 48 mm.).

S. melas.

One male. Expanse, 39 mm. (tip to tip, 36 mm.).
Largest female. Expanse, 60 mm. (tip to tip, 52 mm.).

Typical female *muirheadi* (in Coll. Rothschild, Tring Museum, *ex* Felder Collection) has only two apical, hyaline streaks, whilst *horishana* and *hoppo* have three. *Melas always* has three and larger than in *horishana* or *hoppo*. The variation in the number of these streaks in *muirheadi* is not so important because in the series of sixteen males and females in the B.M. Coll., one finds males, and also females, with two and also with three streaks, so that this variation is evidently not sexual. Typical *muirheadi*, according to Felder, should have eight hyaline streaks and spots on the fore-wing, but some have eight and others seven. What is more important is the fact that in all these sixteen specimens of *muirheadi*, with two exceptions, there is a clear space of the black ground-colour—more marked in some specimens that in others—from costa to above tornus, as in Matsumura's figure of *dichotoma*, Leech (Senchū Zukai, p. 66, pf. 35.16, ♀) (= *nigrifrons*, Wilem., nec *dichotoma*, Leech). These two exceptions are two males, one from "Hongkong (Bowring)" and the second from "China, Kweichow province, vi, vii.1880, ex Leech Coll." In these two specimens the clear, black space from costa to tornus is barred by the fourth spot of the outer series of spots above vein 3. As previously stated in *S. alikangiensis*, the male from Hongkong was selected by Hampson for representing *muirheadi* in his plate (cf. p. 421). In this specimen the subcostal, median nervure, a broad fascia on and below vein 1, and the other veins, are yellow. This specimen is really an aberration amongst the sixteen examples of *muirheadi* in the B.M. Coll., of which more typical specimens were available for figuring. I have endeavoured to obtain Felder's male type of *muirheadi*, and wrote to Prof. Rebel of the Naturhistorisches Museum, Vienna, to request the loan of it for examination, but he replied that the type was not deposited in that Museum. It appears that male type *muirheadi* was never included in the Novara Reise Collection which is deposited in that Museum, but was described later on by Felder, and should therefore be found in his private collection. This collection is deposited at Tring Museum. Lord Rothschild, however, informs me that he only possesses the female type of *muirheadi*, and has kindly lent it to me for examination. The male type therefore seems to be lost. The female type is

labelled "Felder Colln., *Amata muirheadi*," and is presumably the type, but there is no type-label attached. In 1862, when Felder described this species, not much pains was taken by entomologists absolutely to identify their types by any special labels.

Felder's original description runs as follows : (*ex* Wien Ent. Mon., 6, p. 37, 1862).

"56. *Syntomis muirheadi*, Nob.

Alis anticis nigricantibus, maculis tribus vittae formibus aliisque quatuor pone discum hyalinis, posticis, margine costali et externo exceptis, hyalinis, fronte scapulis-que luteis, cingulis abdominalibus ochraceis. ♂♀.

Regiones montanas circa Ningpo incolit ista, S. diaphanae Kollar affinis."

Range :—

B.M. Coll.
Wileman Coll. } No specimens from Formosa.
Formosa only.
Regional range. Indo-Australian.

Type :—

Hokkaidō. Impl. Univ., Sapporo. } *horishana.* ♀. Formosa, Horisha (*Ch. Polisia*).

8. **Syntomis hoppo,** Matsumura.

Nom. Jap. *Hoppo-Kanoko.*

Syntomis hoppo, Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.E.T.]) Suppl., 3, pp. 69, 70, No. 616, pf. 35.20, ♀ (1911) ♀, Formosa, Hoppo. N.J. *Hoppo-Kanoko.*

As previously remarked by me, under *Syntomis horishana*, I believe that *hoppo* is referable to *Syntomis muirheadi*, Feld., or *Syntomis melas*, Wlk. Refer to *horishana* (p. 429).

Range :—

B.M. Coll.
Wileman Coll. } No specimens.
Formosa only.
Regional range. Indo-Australian.

Type :—

Hokkaidō Impl. Univ., Sapporo. *hoppo.* ♀. Formosa, Hoppo.

Syntomis persimilis, Leech. (Plate XX, fig. 4, *S. persimilis persimilis.*)

9. **Syntomis persimilis perixanthia,** Hampson, subspecies.

Nom. Jap. *Kisuji-Taiwan-Kanoko* (6). *Taiwan-Ki-Kanoko-Ga* (10). *Mikan-Kanoko* (17).

1. *Syntomis perixanthia*, Hmpsn., Leech, Entom., 31, p. 152 (*in text*) (vii.1898), *non descr.* by Hampson, or Leech, in vii.1898.
2. *Syntomis persimilis*, Leech, Entom., 31, p. 152, ♀ (vii.1898) ♂ *nec* ♀, China (W.C.), Nitou, *primum descr.*
3. *Syntomis perixanthia*, Hmpsn., Leech, Trans. Ent. Soc. Lond., p. 321 (ix.1898), *non descr.* by Hampson, or Leech, in ix.1898.
4. *Syntomis persimilis*, Leech, Trans. Ent. Soc. Lond., p. 322 (ix.1898).
5. *Syntomis perixanthia*, Hampson, Cat. Lep. Phal., i, p. 97, No. 153, pf. 3.17, ♀ (16.xii.1898) ♀, Formosa, *primum descr.*
6. *Syntomis perixanthia*, Hmpsn., Miyake (T.) Annot. Zool. Jap. [E.T.], 6, pt. 2, p. 81 (1907) N.J. *Kisuji-Taiwan-Kanoko* = *persimilis perixanthia.* Formosa, Sekijō.

7. *Syntomis perixanthia*, Hmpsn., Seitz (*error determinationis*, nec *S. perixanthia*, Hmpsn.) in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 39, pf. 9. f, (0) (1909) = *persimilis sinensis*. Cf. (12), p. 445.
8. *Amata perixanthia sinensis*, Rothschild, subsp., Nov. Zool., 17, p. 435, ♂ (1910) ♂, China, Kweichou, Moupin (W.C.; W.).
9. *Syntomis interrupta*, Wileman, Entom., p. 220, ♂ (viii.1910) ♂, Formosa = *persimilis perixanthia*.
10. *Syntomis perixanthia*, Hmpsn., Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]) Suppl., 3, p. 61, No. 602, pf. 35.6, ♀ (1911) N.J. *Taiwan-Ki-Kanoko-Ga* = *persimilis perixanthia*.
11. *Amata perixanthia sinensis*, Rothschild, Nov. Zool., 19, p. 375, pf. 3.17, (0) (1912).
12. *Syntomis perixanthia*, Hmpsn., Seitz (*error determinationis*, nec *S. perixanthia*, Hmpsn.) in Seitz's Gross. Schmett. [E. ed.], Pal. 2, p. 445 (1912) = *perixanthia sinensis*. Cf. (7), p. 39.
13. *Syntomis perixanthia*, Hmpsn., Zerny in Junk's Lep. Cat., 7, p. 25 (1912).
14. *Syntomis persimilis*, Leech, Zerny in Junk's Lep. Cat., 7, p. 25 (1912).
15. *Syntomis perixanthia*, Hmpsn., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 70 (1913).
16. *Syntomis interrupta*, Wilem., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 79 (1913) = *persimilis perixanthia*.
17. *Syntomis* sp. ? Shiraki, Taiwan Sōtokufu Nōji Shikenjō, No. 68 [J.T.], 8, p. 427, No. 274, pf. 43.1–4 (1, p. i). (3.xii.1913.) N.J. *Mikan-Kanoko* = *persimilis perixanthia*. Plate unpublished.
18. *Amata perixanthia sinensis*, Rothsch., Hampson, Cat. Lep. Phal. Suppl., i, p. 36 (1914).
19. *Amata interrupta*, Wilem., Hampson, Cat. Lep. Phal. Suppl., i, p. 34, No. 138*a*, pf. 2.32, ♀ (1914), ♀ from Hongkong.
20. *Syntomis perixanthia*, Hmpsn., Strand, Deutsch. Ent. Zeitschr., Berlin, **1915**, H. i, p. 30 (1915).
21. *Syntomis perixanthia*, Hmpsn., var. (?) *perixanthoides*, Strand, Deutsch. Ent. Zeitschr., Berlin, **1915**, H. i, p. 30, ♂ (1915) ♂, Formosa, Kosempo.
22. *Amata perixanthia*, Hmpsn., Shiraki in Report Proc. 3rd Ent. Meeting, Pusa, 2, p. 661 (o.l, p. i) (1920), N.J. *Mikan-Kanoko*.

The citations refer to the species *persimilis* and to the three subspecies, *S. persimilis persimilis*, *S. persimilis perixanthia*, and *S. persimilis sinensis*.

S. persimilis perixanthia is the only one which is known, so far, to occur in Formosa.

Antennae :—

S. persimilis persimilis. Male type. Apical one-fourth white-tipped, minutely ciliate, setae double the length of cilia (u.m.).

S. persimilis perixanthia. Male. Apical one-fifth white-tipped, minutely ciliate, setae double the length of cilia, longer towards apex; *ex* "Kanshirei, 12.iv.1909," in B.M. Coll. (u.m.)

Female type. Incomplete. Very minutely ciliate (u.m.).

Female type *interrupta*. Very minutely ciliate (u.m.).

S. persimilis sinensis. Male type. Apical one-fourth white-tipped, minutely ciliate, setae double the length of cilia, longer towards apex (u.m.).

	Frons.	Patagia (collar).	Tegulae.
S. persimilis persimilis.	Yellow. (*Capucine-yellow.*)	Black.	Yellow.
S. persimilis perixanthia.	Orange. (*Light orange-yellow.*)	Orange.	Orange.
S. persimilis sinensis.	Yellow. (*Light orange-yellow.*)	Yellow.	Yellow.

Note that the colours in italics, as above, more accurately represent the actual colours according to Ridgway's "Color Standards" (Plate III).

Persimilis was described by Leech in July, 1898, from Nitou, China (W.C.), and he also remarks in the body of the text " allied to *S. perixanthia*, Hampson " (1 and 2). Hampson had not then published *perixanthia*. In September, 1898, Leech records (3) the capture of *perixanthia* in Western China and Formosa, but does not describe it, as this species, already described by Hampson in manuscript, was awaiting publication at the time he cited Hampson (" Cat. Lep. Phal. i, ined., 1898 ") as the author of the name *perixanthia*. Hampson's *perixanthia*, however, was not published until December 16, 1898 (5), so that it is (as pointed out also by Strand (20)) a *nomen nudum*, and *persimilis*, Leech, is the valid name of the species, which includes the following subspecies :—

1. *S. persimilis persimilis*, Leech, China (W.C.). (Plate XX, fig. 4.)
2. *S. persimilis perixanthia*, Hampson, Formosa.
3. *S. persimilis sinensis*, Rothschild, China (W.C.).

Numbers one and three may possibly be forms of one subspecies as they both come from West China, and there is a female specimen of each from Omeishan, China (W.C.) in the B.M. Collection.

Should *persimilis* and *perixanthia* eventually be regarded as two distinct species then the name *perixanthia*, Hmpsn., will stand for the species *perixanthia*, which was first described by Hampson (5) as a species from Formosa, and it still stands for the subspecies. Hampson does not figure the type of *persimilis*, which he regarded as an aberration of *perixanthia* (5), so it is figured herewith (Plate XX, fig. 4). Miyake (6) records *perixanthia*, possibly identified from Hampson's figure, from Sekijō, Formosa.

The species described by me as *interrupta* sinks to subspecies *persimilis perixanthia*. I have compared my male type with the type and series of *perixanthia* in the B.M. Collection, and think that the two moths are certainly conspecific and that I have evidently redescribed *perixanthia* as *interrupta* in error. Hampson also seems to have overlooked this fact, as he has placed *interrupta* as No. 138*a* (19) after *grotei* instead of referring it to *perixanthia* (5, No. 153). He figures the female from Hongkong, " ex. Coll. Moore, Lloyd," in his plate (19). Matsumura (10) ignores the fact that Miyake had already given *perixanthia* a Japanese name and names it *Taiwan-Ki-Kanoko-Ga*. He also gives India as a habitat, but I do not know of any authority for this. " Common in Formosa." Seitz (7) on p. 39 cites and figures *perixanthia* as " *Syntomis perixanthia* " in 1909, and in 1912 (12), in Errata and Addenda, p. 445, refers his figure to *sinensis*, Rothsch., anent which Strand has offered some remarks (20), to which I refer further on.

Shiraki (17), in a written, marginal annotation made in my copy of his work, refers *Syntomis* sp. to *Amata perixanthia*. He describes the life-history, giving details in Japanese concerning the ovum, larva, pupa and imago, and also refers the reader to a plate *not yet* published, pf. 43.1 to 4. I understand from him that this plate is not likely to be published at present owing to the inability of the Formosan Government Department concerned to provide the necessary funds. In a later publication (22) he traces the life-history of *perixanthia*, and remarks, " I think that *Amata lucerna*, Wilem., is probably a synonym of this species." He does not, however, give his reasons for this conjecture, and it would be interesting to know whether he has bred *perixanthia* and *lucerna* from similar larvae, which would settle the question. As far as I can see from the examination of the material in the B.M. and Wileman Collections they are certainly distinct species.

Strand directs (20) attention to the fact that *perixanthia*, Hmpsn., is a *nomen nudum*. I have examined his male type of (?)var. *perixanthoides*

(Plate XX, fig. 10) and have compared it with Hampson's female type of *perixanthia*. The chief difference is that "the hyaline spot below vein 2 of the fore-wing is more acutely produced" than in the female type *perixanthia*. The three males in the B.M. Coll. from Formosa resemble it, and this seems to be the normal marking so that it seems scarcely worth while to regard it as a variety. Strand compares his *perixanthoides* with Seitz's figure (7), but seems to be unaware that in 1912 Seitz (12) states that his figure of *perixanthia* (7, pf. 9. f.) is *sinensis*, Rothsch. I have examined the male type of *sinensis* (11, not sexed). The antennae seem to agree with those of *persimilis*.

Leech (2) records his three specimens of *persimilis*, including female type, from Nitou and Omeishan, China (W.C.), as females, but they are *all* males. Hampson calls *persimilis* an aberration of *perixanthia* (5).

Hampson places *interrupta* in the key (5, p. 78) before *polymita*, which has the "Fore-wing with the hyaline markings reduced to spots, no" [hyaline] "spot above vein 2."

Perixanthia has "fore-wing with orange streak below costa and above inner margin, the hyaline patches large," but the *middle spot* of the median series of spots *is above vein 2*. My male type *interrupta* agrees with the male var. *perixanthoides*, Strand, and is, without doubt, referable to *persimilis perixanthia*, subspecies.

Range of S. persimilis perixanthia only :—

B.M. Coll. Formosa. 7 sps. 5 ♂♂, 2 ♀♀ (type *perixanthia*);
Kanshirei (iv, 1,000 ft., Wileman);
Polisia (iii, Sauter);
hab. ign. 1 sp.

Wileman Coll. Formosa. 1 sp. ♂ (type *interrupta*).
Garambi, xi.

Deutsch. Ent. Inst. (Mus.), Berlin. "Sauter Ausbeute."
Formosa.
3 ♂♂. Kosempo, iv, xi; Takau, xi (*perixanthia*).
4 ♀♀. Kosempo, iv, vii, xi (type *perixanthoides*), Chip-chip, ii.

Regional range. Indo-Australian.
Formosa; Hongkong, i (19).

Types :—

B.M. Coll.	*perixanthia.*	♀.	Formosa.
	persimilis.	♂ (*nec* ♀).	China (W.C.), Nitou.
Deutsch. Ent. Inst. (Mus.).	*perixanthoides.*	♂.	Formosa Kosempo, xi.
Tring Mus.	*sinensis.*	♂.	China (W.C.), Kwei-chow prov., vi–vii, 1890.
Wileman Coll.	*interrupta.*	♂.	Formosa, Garambi, xi.

Time of Appearance :—

In Formosa only, iii, iv, vii, xi.
"Three or four broods in the year," bred by Shiraki in iv. and vii.

Food Plants. Kankitsu (Orange, *Citrus* sp.) (17); *Cha* (Tea-plant, *Thea sinensis*, L.); *Banjirō* (Guava, *Psidium Guayava*, Radd.).

10. **Syntomis nigrifrons** (Wileman). (Plate XX, figs. 5 ♂, 6 ♀.)

Nom. Jap. *Ō-Kanoko-Ga* (2).

1. *Amata nigrifrons*, Wileman, Entom., 47, p. 318, ♀ (1914) ♀, Formosa, Karapin.

2. *Syntomis dichotoma*, Leech, Matsumura (*error determinationis*, nec *S. dichotoma*, Leech), Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]) Suppl., 3, p. 66, No. 612, pf. 35.16, ♀ (1911) N.J. *O-Kanoko-Ga*.
3. *Amata deflavata*, Gaede, Deutsch. Ent. Zeitschr., **1926**, II. 2, p. 115, ♂ (1926) ♂, Formosa, Polisha (!) (*recte* Polisia).

Antennae :—Female type, *nigrifrons*. Incomplete. Minutely ciliate, setae longer than male and longer towards apex.

Male type *deflavata*. Incomplete. Minutely ciliate, setae double the length of cilia, longer towards apex.

Hampson does not include this species in his Supplement i of Cat. Lep. Phal., which was published before the description of *nigrifrons* appeared, but in the cabinet of the B.M. Coll. he has placed it near *dichotoma*, Leech.

I have examined the male type of *Amata deflavata*, Gaede (3), Plate XX, fig. 5), and determine it as the male of my female *nigrifrons* (1). In the male there are eight hyaline spots on the fore-wing, in the female there are nine; the spot above vein 5 in the female is a mere dot and this is absent in the male. The female figure of *dichotoma*, Leech, figured by Matsumura (2) is, I think, referable to female *nigrifrons*. In this female figure, however, the minute spot above vein 5 is missing and the tooth, which is projected on to vein 2 from the inner edge of the black hind margin of the hind-wing, only runs half-way up that vein, whilst in female *nigrifrons* this tooth is conjoined to the cell, separating the basal and the outer-marginal spots. It is possible that *dichotoma*, Matsumura (*nec* Leech), may be referable to subspecies *dichotoma formosensis*, Wilem. (cf. p. 436), and that *nigrifrons* may have the prior claim to recognition as the representative of the Formosan subspecies of *dichotoma*, Leech. As far as the material available at present is concerned *dichotoma*, Matsumura (*nec* Leech), is certainly referable to *nigrifrons*. *Dichotoma formosensis* has a yellow frons and *nigrifrons* has a black frons. There is a clear space (from costa to above tornus) of the blackish-blue ground-colour between the series of median and post-median spots in *nigrifrons*. In *dichotoma formosensis* there is no clear space, as all the hyaline spots are placed closer together and the second spot of the median series almost touches the fourth spot of the post-median series.

Range :—

B.M. Coll. No specimens, a coloured figure of type.
Wileman Coll. Formosa, Karapin, type ♀ (vi, 3,000 ft.).
Formosa only.
Regional range. Indo-Australian.

Types :—

Wileman Coll.	*nigrifrons*.	♀.	Formosa, Karapin.
Zool. Mus. Berlin.	*deflavata*.	♂.	Formosa, Polisha (*recte* Polisia). v.1910 [1,000–2,000 ft. ?, *circa*].

Syntomis dichotoma, Leech.

11. Subspecies **Syntomis dichotoma formosensis**, subspecies nov.

(Plate XX, figs. 7 ♂, 8 ♀.)

Nom. Jap. *Unnamed.*

The following citations which refer to *S. dichotoma*, Leech, are given for convenience of reference.

1. *Syntomis dichotoma*, Leech, Entom., 31, p. 153 ♂, ♀ (1898) ♂, ♀, China (W.), Moupin.
2. *Syntomis dichotoma*, var. *concurrens*, Leech, Entom., 31, p. 153, ♂ (1898) ♂, China (W.), Kiating-fu.

3. *Syntomis dichotoma*, Leech, Hampson, Cat. Lep. Phal., i, p. 100, pf. 4.1, ♂ (1898).
4. *Syntomis dichotoma*, Leech, Trans. Ent. Soc. Lond., p. 323 (1898).
5. *Syntomis dichotoma*, ab. *concurrens*, Leech, Hampson, Cat. Lep. Phal., i, p. 100 (1898).
6. *Syntomis dichotoma*, Leech, Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 39, pf. 9. e, (0) (1909).
7. *Syntomis dichotoma*, Leech, ab *concurrens*, Leech, Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2. 39 (0) (1909).

Seitz's figures (6, 7) are typical and agree perfectly with Leech's types.

Antennae :—Male type, *dichotoma formosensis*. Incomplete, basal joints only of one antenna. Minutely ciliate at base, same as *nigrifrons* (♂ *deflavata*) (u.m.).

Female type. Minutely ciliate, setae longer than male and longer towards apex (u.m.).

I have two specimens, male and female, of a *Syntomis* from Formosa which have been lent to me by Dr. T. Shiraki, of Taihoku, Formosa, for determination. They are localised as "Formosa, Kōshun, 1918, iv.25–v.25, J. Sonan, K. Miyake, M. Yoshino." In these two specimens the hyaline spots are arranged more like they are in *dichotoma*, Leech, from China, than in *nigrifrons*, Wilem. (cf. p. 435), and they are decidedly close to Leech's species. I think, however, that at present they are worthy of subspecific rank, and therefore name them *dichotoma formosensis* for the reasons given below. The figure of *dichotoma*, Leech, from Nanto, Formosa, given by Matsumura (cf. 2, *nigrifrons*), represents *nigrifrons* much more closely than *dichotoma* and I have therefore referred it to *nigrifrons*. Matsumura says that *dichotoma* is not rare in Formosa; his Japanese name for Leech's species may be transferred to *nigrifrons*. It is possible that *dichotoma formosensis* may eventually have to be sunk to *nigrifrons*, which will then become the representative of the subspecies in Formosa.

My reasons for making this subspecies are as follows :—

1. The ground-colour of *formosensis* is black with a pervading bluish sheen, whilst *dichotoma* is black with a slight purplish reflection.

2. The frons of *formosensis* is naples-yellow; in *dichotoma* it is cream-coloured; in *nigrifrons* it is black.

3. The fore-wings are rather narrower and the hyaline spots are somewhat smaller in *formosensis* than they are in *dichotoma*, and there is also a short white fringe beneath the apex of fore-wing in *dichotoma* which is absent in *formosensis*. One female of the series in B.M. Coll. of *dichotoma* from China (W.), Moupin, agrees remarkably well with female *formosensis* in markings, but has a cream-coloured frons.

4. The tooth on inner edge of the black hind-marginal border of hind-wing extends further up vein 2 towards the cell in *formosensis* than in *dichotoma*.

5. The tarsi of all the legs are conspicuously white in *dichotoma*. In *formosensis* they are (where present) dull greyish white, or brown.

6. I can discover no differences in the antennae sufficient to separate the two forms as species, but think that *formosensis* may provisionally stand as a subspecies.

I have compared my specimens of *nigrifrons* and *dichotoma formosensis* with a series of ten males and females of *dichotoma* in the B.M. Coll., which are all from China (W.).

Range of S. dichotoma formosensis :—Formosa.

B.M. Coll.
Wileman Coll. } No specimens from Formosa.

Range of S. dichotoma dichotoma :—China.

B.M. Coll. China (W.), max. alt., Kiating-fu, 1,070 ft. (3).

Regional range. { *formosensis.* Indo-Australian. / *dichotoma.* Palaearctic.

Types :—

B.M. Coll. { *dichotoma.* ♂♀, China (W.), Moupin, vi. / *concurrens.* ♂, China (W.), Kiating-fu, vi–viii.

Shiraki Coll. *formosensis.* ♂♀, Formosa, Kōshun.

12. **Syntomis edwardsii,** Butler.

Nom. Jap. *Taiwan-Kanoko* (10). *Taiwan-Hime-Kanoko* (11). *Taiwan-Kanoko-Ga* (13).

1. *Syntomis edwardsii,* Butler, Journ. Linn. Soc. Zool., 12, p. 346, (0) (1876) ♂, Formosa.
2. *Syntomis formosae,* Butler, Journ. Linn. Soc. Zool., 12, p. 346, (0) (1876) ♀, Formosa.
3. *Syntomis emma,* Butler, Journ. Linn. Soc. Zool., 12, p. 350, 1876, (0) (1876) ♀, China (E.), Foo-choo-foo (= Foochow).
4. *Syntomis edwardsi,* Btlr., Hampson, Cat. Lep. Phal., i, p. 104, pf. 4.11, ♂ (1898) ♂, Formosa.
5. *Syntomis formosae,* Btlr., Hampson, Cat. Lep. Phal., i, p. 98, pf. 3.26, ♂ (1898) ♂, China (E.), Chusan Is.
6. *Syntomis tetrazonata,* Hampson, Cat. Lep. Phal., i, p. 101, pf. 4.4, ♂ (1898) ♂, Formosa.
7. *Zygaena edwardsii,* Btlr., Kirby, Cat. Het., p. 92, No. 37 (1892).
8. *Zygaena formosae,* Btlr., Kirby, Cat. Het., i. p. 92, No. 36 (1892).
9. *Zygaena emma,* Btlr., Kirby, Cat. Het., i, p. 92, No. 38 (1892).
10. *Syntomis formosae,* Btlr., Matsumura, Cat. Ins. Jap. (Nihon Konchū Sōmokuroku [J.E.T.]), i, p. 171, No. 1441 (18.viii.1905), N.J. *Taiwan-Kanoko.*
11. *Syntomis taiwana,* Miyake (T.), Annot. Zool. Jap., 6, pt. 2, p. 81, ♀ (1907) ♀, Formosa, Shabōsan, N.J. *Taiwan-Hime-Kanoko.*
12. *Syntomis formosae,* Btlr., Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 39, pf. 9. *e* (0) (1909).
13. *Syntomis formosana* (*sic*), Btlr. (*error pro S. formosae,* Btlr.), Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]), Suppl., 3, p. 61, No. 603, pf. 35.7, ♀ (1911), N.J. *Taiwan-Kanoko-Ga.*
14. *Syntomis taiwana,* Miyake (T.), Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]), Suppl., 3, p. 62, No. 604, pf. 35.8, ♀ (1911), N.J. *Taiwan-Hime-Kanoko-Ga.*
15. *Syntomis edwardsi,* Btlr., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 68, pf. 10. *g,* (0) (1912).
16. *Syntomis formosae,* Btlr., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 69 (1913).
17. *Syntomis taiwana,* Miyake (T.), Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 79 (1913).
18. *Syntomis taiwana,* Miyake (T.), Hampson, Cat. Lep. Phal. Suppl., i, p. 39, (1914) (under *edvardsi*).
19. *Syntomis edwardsi,* Btlr., Strand, (*error determinationis* nec *S. edwardsi,* Btlr.), ab. *kosemponicola,* Strand, Deutsch. Ent. Zeitschr., Berlin, **1915,** H. i, p. 32, (0) (1915), ♂, Formosa, Kosempo.
20. *Syntomis tetrazonata,* Hmpsn., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 72, pf. 10. *l* (0) (1913) [Plate not issued yet, in German text only].
21. *Syntomis formosae,* Btlr., (?) var. *frontis,* Strand, Deutsch. Ent. Zeitschr., Berlin, **1915,** H. i, p. 32, ♂ (1915) ♂, Formosa.
22. *Syntomis tetrazonata,* Hmpsn., var. *tainanensis,* Strand, Deutsch. Ent. Zeitschr., Berlin, **1915,** H. i, p. 33, ♂ (1915) ♂, Formosa.
23. *Syntomis taiwana,* Miyake, (T.), Marumo in Nagano's Coll. Essays Nawa [E.T.], p. 23 (1917).

Antennae :—Male type *edwardsii.* Incomplete.

Male *edwardsii.* White-tipped, minutely ciliate-setose, with setae double the length of cilia, somewhat acuminate-serrate-setose especially towards apex; *ex* " Takow, 26.x.1905," Wileman Coll.

Male *formosae.* Incomplete. White-tipped, minutely ciliate-setose, with setae double the length of cilia, somewhat acuminate-serrate-setose especially towards apex; *ex* " Chusan Islands," Hampson's figure.

Female type *formosae.* Incomplete. Minutely bi-acuminate-serrate-setose, single, or paired, setae at each joint (all u.m.).

Hampson places *formosae,* Btlr., *tetrazonata,* Hmpsn., and *edwardsii,* Btlr., in Section C (*Syntomis,* 5, p. 76). " Antennae simple in both sexes. Hind

tibiae and tarsi of male thickly fringed with rough scales, the apex of hind-wing produced." The antennae, however, under the microscope, are *not* "simple."

According to Hampson (5) *edwardsii*, *formosae*, and *tetrazonata* have black frons, orange patagia (collar) and black tegulae, and *tetrazonata* has the first segment of hind tarsus white, which is not stated to be the case in his diagnosis of *edwardsii* and *formosae*.

I employ the terms patagia for the collar-tippets and tegulae for the wing-base covers in the contrary sense to Hampson, viz. my patagia equal Hampson's tegulae, and my tegulae equal Hampson's patagia.

I have examined the series of *edwardsii*, *formosae*, and *tetrazonata* in the B.M. and Wileman Collections, including all types. I have also examined Strand's types of varieties and aberrations of these species and have come to the conclusion that these three supposed species are all forms of one variable Formosan species, viz. *edwardsii*, in which conclusion I am supported by Strand (21, p. 33). *Edwardsii* therefore supersedes *formosae*, because it is the first name in order of publication on the page (1 and 2, p. 346) in which *edwardsii* and *formosae* were simultaneously described. An analysis of the series of *edwardsii*, *formosae*, and *tetrazonata* produces the following results :—

S. edwardsii :—

	Antennae.	Frons.	Patagia (collar).	Tegulae.
3 ♂♂, Formosa.	Incomplete.	Black.	Orange. (*Capucine-yellow.*)	Black.
1 ♂, Formosa, Takow.	White-tipped.	Yellowish.	Orange. (*Capucine-yellow.*)	Black.
1 ♂, China, Fokien, Samsah.	White-tipped.	Black.	Orange. (*Capucine-yellow.*)	Black.

Note that Capucine-yellow represents more accurately the actual colour according to Ridgway's "Color Standards" (Plate III).

Making five specimens, all males (*no females*), with abdominal orange bands on basal and fifth segments and a lateral series of two, abdominal, orange spots on the intermediate segments between first and fifth abdominal bands as described by Hampson in his description and key-diagnosis (5).

In one male specimen from Takow the lateral spots are *semi-obsolescent*; in this it approaches closely to the female type of *formosae*, which has the two abdominal bands but no lateral spots. The fore-wings are tipped at apex with white cilia as is the case also in *formosae*, *taiwana* (11) and *cysseus*, Stoll. (Cf. p. 441.)

S. formosae :—

Males.	Antennae.	Frons.	Patagia (collar).	Tegulae.
2 ♂♂, Formosa.	Incomplete.	Black.	Orange. (*Capucine-yellow.*)	Black.
2 ♂♂, Formosa.	Black-tipped.	Black.	Orange. (*Capucine-yellow.*)	Black.
2 ♂♂, Formosa.	White-tipped.	Yellowish.	Orange. (*Capucine-yellow.*)	Black.
2 ♂♂ China, Chusan Is.	White-tipped.	Black.	Orange. (*Capucine-yellow.*)	Black.

Note that Capucine-yellow represents more accurately the actual colour according to Ridgway's "Color Standards" (Plate III).

The above eight males include Strand's three types of *frontis*, *tainanensis*, and *kosemponicola*.

S. formosae and S. emma :—

Females.	Antennae.	Frons.	Patagia (collar).	Tegulae.
1 ♀, China, Foochow.	Incomplete.	Black	Orange. (*Capucine-yellow.*)	Black.
4 ♀♀, Formosa.	Incomplete.	Black.	Orange. (*Capucine-yellow.*)	Black.
1 ♀, Formosa.	Black-tipped.	Black.	Orange. (*Capucine-yellow.*)	Black.

Note that Capucine-yellow represents more accurately the actual colour according to Ridgway's "Color Standards" (Plate III).

The abdominal, orange bands in the series of eight male *formosae* vary in number from four to seven, some of these bands being more or less obsolescent in certain specimens. In the series of six females the obsolescence of the orange bands is more marked than in the males, and only in one specimen from Foochow, China, are these seven bands present as in Hampson's non-typical male figure from the Chusan Islands. In the female type of *formosae* there are only two bands present, the same number as in male type *edwardsii*. None of these males or females has the two, lateral, abdominal, orange spots of *edwardsii*, with the exception of the female type *emma* from China. In this type the two lateral spots are well-marked commencements of the almost imperceptible and practically obsolescent bands connecting them with the abdominal dorsum. To recapitulate, there are of :—

Edwardsii, two males from China and Formosa with white-tipped antennae.

Formosae, two males from China and two males from Formosa with white-tipped antennae, and two from Formosa with black-tipped antennae.

Edwardsii, one male from Formosa with yellowish frons (typically black).

Formosae, two males from Formosa with yellowish frons (typically black) (also cf. Strand's var. *frontis* for his three specimens with yellow frons and a varying number of abdominal bands (21, p. 32)).

The specimens with the yellowish frons I regard as aberrations and not typically representing their respective forms. One of the males from the Chusan Islands, China, which has white-tipped antennae is the specimen selected by Hampson to be figured as the non-typical male of the female type *formosae* (5), and, I suppose, in the absence of a male type, must be regarded as having typical characteristics, in which case the antennae are typically white-tipped. *Perhaps* Hampson's description of the male (5, p. 98) from the Chusan Islands makes it the male type. If that be so it is not labelled "type."

S. tetrazonata :—

	Antennae.	Frons.	Patagia (collar).	Tegulae.	Hind tarsus.
One male type, Formosa.	Black-tipped.	Black.	Orange. (*Capucine-yellow.*)	Black.	White-tipped.

Note that Capucine-yellow represents more accurately the actual colour according to Ridgway's "Color Standards" (Plate III).

The characters which separate *tetrazonata* from *edwardsii* and *formosae* are, according to Hampson, the four, orange, abdominal bands and the white-tipped first segment of hind tarsus. Amongst the eight males of *formosae*, two Formosan males have this segment coloured brownish-white, three have it coloured chocolate-brown and the tarsi of the remaining one are missing; in the non-typical male from China, Chusan Islands, figured by Hampson, this segment is a brownish or dirty white, in the second Chusan male the abdomen is missing.

Five out of the six females from Formosa and China have this segment chocolate-brown, and the sixth is minus tarsi. In four specimens of *edwardsii* this segment is chocolate-brown, in the fifth, the type, all the legs are missing. One male which was found in the series of *edwardsii* in the B.M. Coll. has frons, patagia and tegulae *all black*, and has been referred by me to *fortunei*, De l'Orza, under the name of subspecies *fortunei formosensis* (cf. p. 443).

As regards Strand's varieties and aberrations :—

1. *Edwardsii* (*formosae*) *frontis* (21) (Plate XX, fig. 14) male with orange frons, may, when compared with the non-typical figured male of Hampson from the Chusan Islands (5), stand as an aberration with an orange frons. The typical frons of *formosae* in type female *formosae* is black.

2. *Edwardsii* (*edwardsi*) *kosemponicola*, (19) (Plate XX, fig. 16) male, which may stand as an aberration, is evidently not referable to *edwardsii* (as Strand states) in any case, but to *formosae*, whether one decides to separate *edwardsii* and *formosae* as species or not. It is quite close to Hampson's figured male of *formosae* from the Chusan Islands (5), the hyaline spots are a little smaller and it has also seven, orange, abdominal bands, although at first sight this is not apparent. Bands two and three (from the metathorax base) are distinctly present, but are concealed on the abdominal dorsum by the contraction of the segmental folds, and thus the lateral markings resemble two orange spots, as in *edwardsii*, but are not so large. In the case of the Chusan male the segments are all well extended without any contraction of the abdomen. The Chusan male expands 28 mm. (tip to tip, 25 mm.) and *kosemponicola* expands 24 mm. (tip to tip, 22 mm.).

3. *Edwardsii* (*tetrazonata*) *tainanensis* (22) (Plate XX, fig. 13) male, may stand as an aberration. Hampson named his *tetrazonata* from an unique male from Formosa. " Hind tarsi with the 1st segment white, abdomen with four orange bands " (5, p. 101). The abdomen of the type *tetrazonata* has been glued on, thus obliterating the second, abdominal, orange band. The hind tarsi are also missing so that one cannot say whether they are *pure white* or not. Type *tetrazonata* and var. *tainanensis* (22) are evidently aberrations of *formosae* with four abdominal bands instead of seven, 5, 6, and 7 (from metathorax base) being absent. In *tainanensis* there are two minute, round, hyaline spots in the post-medial series, just under veins 3 and 6, which distinguish it from the male type of *tetrazonata* and all the other specimens of *edwardsii* and *formosae*. Hampson's type of *tetrazonata* is very faded, rather rubbed and thirty years old.

Female *formosana*, Btlr. (13), figured by Matsumura, is evidently an error for *formosae*. Butler never described any *Syntomis* under the name of *formosana*, but he has described *Euchromia formosana* (cf. *E. elegantissimia*, 8, p. 448), which is an entirely different species. Matsumura evidently intends his figure to be taken for *formosae*, but it does not satisfactorily represent that species. The expanse of his figure is 46 mm. (tip to tip, 42 mm.). Type female *formosae* expands 28 mm. (tip to tip, 24 mm.), so that there is a considerable discrepancy in expanse. Then in *formosae* the tooth projected from the inner edge of the black hind margin of hind-wing on to, and up, vein 2, is scarcely apparent in the figure. Perhaps it did not exist in the moth from which the figure is taken. There seem to be five, abdominal, orange bands, and in this it rather resembles type female *emma*, in which there are five bands, two, three and five being more or less obsolescent. If the moth figured actually be *formosae*, then it must be an abnormally large specimen of 46 mm. The figure seems to be inexact and misleading.

Miyake (11) described the female type of his *taiwana* from Shabōsan, Formosa.

He states that it is " Allied to *cyssea*, Stoll, but the hyaline spots of fore-wing much larger. A few white cilia below apex. Hind-wing with conjoined hyaline spots as in *S. fortunei*, De l'Orza, instead of two separate spots. Exp. 31 mm."

In the series of fifteen specimens of *fortunei* in the B.M. Coll. there is only one specimen (the melanic ab. *erebina*, Btlr., Hampson's ab. 2) without conjoined hyaline spots. *Edwardsii* is also without conjoined hyaline spots. In *some* specimens of *cysseus*, Stoll, of which there are thirty-four specimens in the B.M. Coll., *there are also white cilia at apex of the fore-wing*; the expanse, in some cases, is broader than in *edwardsii* and the spots are, sometimes, *larger even than in edwardsii*. In 1916 some correspondence passed between the late Dr. T. Miyake and myself with reference to *taiwana*. I will quote verbatim what he wrote. " In Cat. Lep. Phal., Suppl., i, recently published, Hampson wrote my sp. *Syntomis taiwana* as synonymous with *edwardsii*. Unfortunately I cannot agree with him on this point, because *taiwana* does not bear lateral orange spots between 1st and 5th abdominal bands, and this is the reason why I quoted *S. cyssea* as the nearest ally of *taiwana* " (in *litt.* 15.i.1916). Again he says : " Mr. Marumo of this Institute has recently obtained a male *Syntomis* from Formosa exactly agreeing with my description of *Syntomis taiwana* (especially in not having the lateral orange patches). I have hitherto come across a number of *S.* (*Amata*) *fortunei* specimens, but never have I seen the specimen in which the patches were *entirely* effaced " (in *litt.* 28.xi.1916).

Then again Marumo (23) says : " I have examined the type specimen of the present species [*Amata taiwana*] which was in rather a poor condition, so that I could not distinctly settle the specific value of it. Recently, however, a specimen that had a close resemblance to the specimen has been sent me by Mr. Hirayama, an enthusiastic collector. Since this specimen has been in a very perfect condition, I have been able to make a thorough study and conclude that this was no other than *Amata taiwana*, which is a distinct species and stands nearer to *cyssea*, Stoll, rather than to *edwardsi*, Butl., according to Hampson's diagnosis. Above all the remarkable difference of the present species from *A. eduardsi* is the absence of the lateral series of orange spots between the orange bands of abdomen. Besides the cilia below apex of fore-wing in this species are also white as was stated in the original description, and this may likewise be recognised as one of the distinguishing characters of the species from *edwardsi* and *cyssea*."

(Refer to previous remarks regarding *cysseus*, Stoll, *supra*.)

Marumo does not definitely say that the specimen he received from Hirayama came from *Japan*, but one is led to infer this from the text of his preface, from which it appears that Japanese moths *only* are dealt with in his paper. Miyake therefore may have been mistaken (in *litt.* 28.ix.1916) as regards the habitat of Formosa for this particular specimen. If therefore Japan is its proper habitat, then *edwardsii taiwana* apparently occurs in Japan. I am, however, rather doubtful as to this occurrence, because *edwardsii* has, so far, never been recorded from Japan by other lepidopterists. *Fortunei* is common in Japan, and is known by the black frons, black patagia, black tegulae, and two lateral, orange, abdominal spots, the latter as in *edwardsii*. Might Hirayama's specimen (if from Japan) be an aberrant form of *fortunei* without the two orange, lateral, abdominal spots ? If from Formosa, then, as it does not possess these spots, it should be *taiwana*.

Matsumura (14) gives a figure of female *taiwana*. He does not say whether this was taken from Miyake's type female (or from what source he takes it) which, according to Marumo (23), was in such poor condition that he could not

distinctly settle its specific value. This figure seems to represent an indifferent figure of *edwardsii*. In the Japanese text he compares *taiwana* with the preceding species *formosana*, Btlr., which apparently has a *yellow prothorax* (= ? frons or patagia) (13, *error pro formosae*) (cf. Cat. Ins. Jap., i, p. 171, No. 1441, *Taiwan-Kanoko*). He says that *taiwana* has orange-yellow bands on the first and fifth abdominal segments, *black prothorax* [not yellow as in *formosana*] and measures eight *bu*, five *rin* [= 25·5 mm.]. Typical *edwardsii* has black frons, orange patagia (collar) and black tegulae, orange bands as described above and two orange, lateral, abdominal spots which are absent from *taiwana*, and this *seems* to be the only difference between the two species.

Matsumura's figure of *taiwana* may possibly be referable to *fortunei formosensis*, Wilem. (cf. p. 443), which has a black frons, black patagia (collar) and black tegulae and (as in *fortunei*) two lateral, abdominal, orange spots which are absent from *taiwana*.

According to Matsumura *taiwana* is common in Formosa. He makes no mention of *S. edwardsii*, Btlr., either in his Cat. Ins. Jap. (10) or in Senchū Zukai (13). The former was published in 1905, seven years after Hampson's Cat. Lep. Phal., but *only formosae* is mentioned by Matsumura in both of his publications.

Range :—

S. edwardsii.

B.M. Coll.	Formosa.	2 ♂♂.	Formosa; Takow (viii, Wileman).
Wileman Coll.	Formosa.	1 ♂.	Takow (x, Wileman).

S. formosae.

B.M. Coll.	Formosa.	1 ♂, 2 ♀♀.	Kanshirei (iv, Wileman); Formosa.
Wileman Coll.	Formosa.	2 ♂♂, 2 ♀♀.	Takow (viii, Wileman); Banshōryō (ix, Wileman); Garambi (x, Wileman); Takow (vii, Wileman).

S. tetrazonata.

B.M. Coll.	Formosa.	1 ♂ (type).	
Deutsch. Ent. Inst. (Mus.).	Formosa;	Berlin, "Sauter Ausbeute."	Chip-chip, ii; Kosempo, x–xi; Alikang, x (under *edwardsi*). Kosempo, x–xi (under *formosae*). Tainan, ii (under *tetrazonata*).

Formosa; China (E.); Chusan Is.; India (N.E.); Burma (E. Pegu, 2,000 ft.); Assam (5).

Regional range. Palaearctic and Indo-Australian.

Time of Appearance :—ii, iv, vii to x.

Types :—

B.M. Coll.	*edwardsii.*	♂.	Formosa.
	emma.	♀.	China (E.).
	formosae.	♀.	Formosa.
	tetrazonata.	♂.	Formosa.
Deutsch. Ent. Inst. (Mus.)	*frontis.*	♂.	Formosa, Kosempo.
	kosemponicola.	♂.	Formosa, Kosempo.
	tainanensis.	♂.	Formosa, Tainan.
? Science College, Tōkyō.	*taiwana.*	♀.	Formosa, Shabōsan.

Expanses :—

		Expanse.	Tip to tip.
edwardsii.	♂♂.	30–38 mm.	25–34 mm.
formosae.	♂♂.	26–30 mm.	22–26 mm.
formosae.	♀♀.	26–30 mm.	22–26 mm.
tetrazonata.	♂.	28 mm.	25 mm.

13. **Syntomis fortunei formosensis,** subsp. nov. (Plate XX, fig. 15.)

Nom. Jap. Same as *fortunei,* De l'Orza, viz. Kanoko-Ga.

For citations cf. under *S. fortunei,* below.

Antennae :—Male type *fortunei formosensis.* White-tipped, minutely ciliate-setose, with setae double the length of cilia, apical joints somewhat acuminate-serrate-ciliate.

Male *fortunei,* De l'Orza, *ex* male, "B.M. Coll. Shimonoseki, Japan, June, 1886 *ex* Leech Coll." White-tipped, minutely ciliate-setose, with ? paired setae at ? each joint *more* than double the length of cilia, apical joints somewhat acuminate-serrate-ciliate. The antennae appear to be slightly more robust and the ciliations rather denser than in *fortunei formosensis* (u.m.).

The type was included in the series of *edwardsii* in the B.M. Coll., with which species it had been confounded by Hampson. It is, however, easily separable from *edwardsii edwardsii, edwardsii formosae* and *edwardsii tetrazonata* by its black frons, patagia and tegulae, in which characters it agrees with all the specimens of *fortunei fortunei* in the B.M. and Wileman Colls. This specimen might *possibly* be a black-frons aberration of *edwardsii edwardsii,* but I prefer to refer it to *fortunei.* The antennae do not seem to differ appreciably from the various forms of *edwardsii,* and on this account it might be thought that it should be assigned to that species, but the forms of *edwardsii* have always, unless they be aberrations (cf. p. 438), black frons, orange patagia (collar), and black tegulae, whilst *fortunei* and subspecies *formosensis* are *all black* in these characters. Matsumura in his description of *S. taiwana,* Miyake, which is certainly more extended than Miyake's, says : "*Zen Kyohai zembu kokushoku*" [the prothorax is entirely black]. The lateral, abdominal, orange spots are, of course, obsolete in *taiwana.*

Range of S. fortunei formosensis :—

B.M. Coll.	Formosa.	1 ♂ (type).
Wileman Coll.	Formosa.	No spms.
Regional range.	Indo-Australian.	
	Formosa only.	

Type :—

B.M. Coll. *formosensis.* ♂. Formosa.

Expanse :—16 mm. (tip to tip, 28 mm.).

I have a male of *fortunei* from Japan, expanse 15 mm. (tip to tip, 26 mm.). This is the smallest one in my collection.

14. **Syntomis fortunei,** De l'Orza.

Nom. Jap. *Hime-Kanoko* (9*a*). (Cf. Addenda, p. 451). *Kanoko-Ga* (10).

1. *Syntomis fortunei,* De l'Orza, Lép. Jap., p. 38, (0) (1869) (0), Japan.
2. *Syntomis erebina,* Butler, Trans. Ent. Soc. Lond., p. 5, (0) (1881) ♂, Japan, Tōkei (= Tōkyō).
3. *Syntomis fortunei,* Boisd. (De l'Orza *nec* Boisduval, *ex err.*), Pryer in Trans. Asiat. Soc. Jap., 12 (2), p. 43, No. 79 (May, 1884).
4. *Syntomis erebina,* Btlr., Leech, Proc. Zool. Soc. Lond., p. 593 (1888).
5. *Syntomis fortunei,* De l'Orza, Leech, Proc. Zool. Soc. Lond., p. 593 (1888).

6. *Syntomis erebina*, Btlr., Leech, Trans. Ent. Soc. Lond., p. 319 (1898).
7. *Zygaena fortunei*, De l'Orza, Kirby, Cat. Lep. Het., i, p. 92, No. 29 (1892).
8. *Syntomis fortunei*, De l'Orza, Hampson, Cat. Lep. Phal., i, p. 104, pf. 4.12, ♂ (1898) ♂, Japan.
9. *Syntomis fortunei*, De l'Orza, Leech, Trans. Ent. Soc. Lond., p. 319 (1898).
10. *Syntomis fortunei*, De l'Orza, Matsumura, Cat. Ins. Jap. (Nihon Konchū Sōmokuroku [J.E.T.]), i, p. 171, No. 1440 (21.viii.1905). N.J. *Kanoko-Ga.*
11. *Syntomis fortunei*, Orza, Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 39, pf. 9. *d*, ♂♀ (1909).
12. *Syntomis fortunei*, Orza, ab. *erebina*, Btlr., Seitz in Seitz's Gross. Schmett. [E. ed.], Pal., 2, p. 39, (ô) (1909).
13. *Syntomis fortunei*, De l'Orza, Matsumura, Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]), Suppl., 3, p. 56, No. 593, pf. 34.13, ♀, (1911). N.J. *Kanoko-Ga.*
14. *Syntomis fortunei*, De l'Orza, Zerny in Junk's Lep. Cat., 7, p. 22 (25.vii.1912).
15. *Syntomis fortunei*, De l'Orza, Strand, Deutsch. Ent. Zeitschr., Berlin, 1915, H. i. p. 31 (1915).
16. *Syntomis fortunei*, De l'Orza, ab. *yezonis* Strand, Arch. Naturg., **1916**, 82, A. 2, p. 81 (Jan. 1917), Hampson's "Ab. 1.," ♂.

Antennae :—Male. White-tipped, minutely ciliate setose, with ? paired setae at ? each joint *more* than double the length of cilia, apical joints somewhat acuminate-serrate-ciliate. The antennae appear to be slightly more robust and the ciliations rather denser than in *fortunei formosensis* (Plate XX, fig. 15) from Formosa; *ex* male, B.M. Coll. "Shimonoseki, Japan, June 1886," *ex* Leech Coll.

Female. White-tipped. Bisetose, setae paired at ? each joint; *ex* female, B.M. Coll. "Nagahama, Japan, July, 1886," *ex* Leech Coll. (u.m.).

Pryer in recording this species from Japan says "never at any great elevation" (3). In China, however, it is recorded from six thousand feet in the B.M. Coll.

Butler's type of *erebina* is merely a melanic aberration of *fortunei* (2).

The following localities, mentioned by Leech, are not represented in the B.M. Coll. in which the Leech Collection was incorporated after his death: Yokohama, Nikkō, Oiwake, Tsuruga, all in Japan, and Gensan in Korea; but these specimens may not have entered the B.M. Coll. and may have been distributed elsewhere.

Hampson's "Ab. 1." (8, p. 104) has been named *yezonis* by Strand. It "has the two spots in submedian interspace of fore-wing conjoined as an elongate patch, with a slight yellow streak below vein 1, and speck above vein 2; the spot above vein 6 elongate."

Range :—

B.M. Coll. Japan. 15 sps. unsexed.
HOKKAIDŌ : *Oshima*, Hakodate; YEZO [= HOKKAIDŌ], unlocalised.
HONSHŪ : *Musashi*, Tōkyō;
Ōmi (*Shiga*), Nagahama;
Shimotsuke (*Tochigi*), Nikkō;
Sagami (*Kanagawa*), Hakone;
Nagato (*Yamaguchi*), Shimonoseki;
Japan, unlocalised.

Wileman Coll. Japan. 10 sps. 5 ♂♂, 5 ♀♀.
HOKKAIDŌ : *Oshima*, Junsai Numa, viii.
HONSHŪ : *Settsu* (*Hyōgo*), Kobe, vi;
Musashi (*Kanagawa*), Hoshikawa, vii;
Shimotsuke (*Tochigi*), Nikkō, vii.
KYŪSHŪ : *Higo*, Karimata Dake, vi.

Deutsch. Ent. Inst. (Mus.). Berlin, "Sauter Ausbeute."
Japan. 6 sps. unsexed.
HONSHŪ : *Musashi*, Yokohama, v–vi.

Japan : Hokk. Honsh., Shik., Kyū. (13); Korea (5).
China (C.), 6,000 ft. (B.M.); Ningpo (5, Herz); Kiukiang (5, Pratt).

Types :—

Where? *fortunei.* (0). Japan.
B.M. Coll. *erebina.* ♂. Japan, Tōkyō, melanic ab.
B.M. Coll. *yezonis.* ♂. Japan, Yezo (= Hokkaidō), Hampson's Ab. 1.

Time of Appearance :—v to viii.

Expanse :—" In expanse this species ranges from 28 to 40 millim." (4, Leech).

ERESSA.

Walker, List. Lep. Ins. B.M., i. 149 (1854); Hampson, Cat. Lep. Phal., i, p. 115 (1898).

15. **Eressa confinis** (Walker).

Nom. Jap. *Unnamed.*

1. *Glaucopis confinis*, Walker, List. Lep. Ins. B.M., i, 149, (0) (1854) ♂, India (N.).
2. *Eressa confinis*, Wlk., Moore, Lep. Ceyl., 2, p. 36, pf. 95·6, ♂ (1882).
3. *Eressa musa*, Swinhoe, Proc. Zool. Soc. Lond., p. 290, pf. 20.1, (0) (1885) ♀, India (W.).
4. *Syntomis musa*, Swinh., Hampson, Moths Ind., i, p. 222 (10, I, 1893).
5. *Syntomis confinis*, Wlk., Hampson, Moths Ind., i, p. 223 (10, I, 1893).
6. *Eressa confinis*, Wlk., Hampson, Cat. Lep. Phal., i, p. 116, tf. 38, ♂ (1900).
7. *Eressa confinis*, Wlk., Hampson, Journ. Bombay Nat. Hist. Soc., 13, p. 223, tf. ♂ (1900).
8. *Eressa catoria*, Swinhoe, Ann. Mag. N.H., (7) 6, p. 305, ♂ (1900) ♂, India (W.).
9. *Syntomoides finitima*, Wileman, Entom. 43, 220, ♂ (1910) ♂, Formosa.
10. *Eressa confinis malaccensis*, Rothschild, Nov. Zool., 17, p. 437, ♂ (1910) ♂, Penang.
11. *Eressa confinis intensa*, Rothschild, Nov. Zool., 17, p. 438, ♂ (1910) ♂, India, Belgaum (W.).
12. *Eressa confinis malaccensis*, Rothschild, Nov. Zool., 19, p. 376, pf. 4.6, (0) (1912).
13. *Eressa confinis intensa*, Rothsch., Rothschild, Nov. Zool. 19, p. 376, pf. 4.7, (0) (1912).
14. *Eressa confinis*, Wlk., and forms, Zerny in Junk's Lep. Cat., 7, p. 32 (25.vii.1912).
15. *Eressa confinis*, Wlk., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 83 (1913).
16. *Eressa confinis malaccensis*, Rothsch., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 83, pf. 12. *a* (0) (1913).
17. *Eressa confinis intensa*, Rothsch., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 83, pf. 12. *b* (0) (1913).
18. *Ceryx finitima*, Wilem., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 88 (1913).
19. *Eressa finitima*, Wilem., under *confinis*, Wlk., Hampson, Cat. Lep. Phal., Suppl., i, p. 46 (1914).
20. *Eressa confinis*, Wlk., Strand, Deutsch. Ent. Zeitschr., Berlin, **1915**, H. i, p. 34 (1915).

Antennae :—

Male type *confinis.* } Bipectinate.
Male type *confinis intensa.* }
Male type *finitima.* Missing.

There is one male (minus antennae) of *confinis* in the B.M. Coll. series, " Formosa, Takow, 3.v.1906," which compares well with a male from " S. Shan States, Kalaur, 4,000 ft." It also compares very favourably with the type male *confinis* from India (N.). It agrees almost perfectly with the Kalaur specimen, and, as regards the type, it differs as follows :—

1. The elongate hyaline patch below vein 2, commencing below middle of cell, is more pointed and produced outwardly instead of being squared off outwardly, and also is rather shorter.

2. The series of ventral, yellow spots are, owing to wear and tear, almost obsolescent, but the dorsal and lateral spots are well marked as in type.

The species described by me as *finitima* (9) has been referred by Hampson (19) to *confinis* and agrees satisfactorily with the male type of *confinis intensa*, Rothschild (11). It agrees better still with a specimen from " Burma, Maymyo, v.1912 (Mackwood)," in the B.M. Coll. It is smaller than the type in which the hyaline spots are somewhat larger; also the dorsal, lateral, and ventral, yellow spots are more developed than in type and have almost a tendency to coalesce

and form bands on the first three segments. Type *finitima* has no antennae. Strand (20) also records *confinis* from Formosa. In the B.M. Coll. Hampson labels *catoria* (8) and *musa* (3) as aberrations, and there are coloured typical figures of *confinis intensa* and *confinis malaccensis* in the same drawer.

Range of species E. confinis, subspecies, and aberrations :—

B.M. Coll.	Formosa.	1 sp. ♂.
		Takow (v, Wileman) *confinis intensa.*
Wileman Coll.	Formosa.	1 sp. ♂ (type *finitima*).
		Kanshirei, vii, 1,000 ft.
Deutsch. Ent. Inst. (Mus.).		Berlin, " Sauter Ausbeute."
	Formosa.	4 sps.
		Alikang, x–xi, *confinis.*

Formosa; Penang (10); Burma (6); Ceylon (3); India (6); Tonkin (10); Mergui I. (M.C. Vind, 14.)

Regional range. Indo-Australian.

Types :—

B.M. Coll.	*catoria.*	♂.	India (W.), Jaintia Hills.
	confinis.	♂.	India (N.).
	musa.	♀.	India (W.), Bombay.
Tring Mus.	*intensa.*	♂.	India (W.), Belgaum, vi.
	malaccensis.	♂.	Penang.
Wileman Coll.	*finitima.*	♂.	Formosa, Kanshirei.

Time of Appearance :—Formosa, v, vii, x–xi.

16. **Eressa catena** (Wileman). (Plate XX, fig. 9.)

Nom. Jap. *Unnamed.*
1. *Syntomoides catena*, Wileman, Entom., 43, p. 220, ♀ (1910) ♀, Formosa.
2. *Ceryx catena*, Wilem., Seitz in Seitz's Gross. Schmett. (E. ed.), Ind.-Aust., 10, p. 89 (1913).
3. *Eressa catena*, Wilem., Hampson, Cat. Lep. Phal., Suppl., i, p. 47, No. 212*a*, pf. 3.12, ♀ (1914).

Antennae :—Female type. Acuminate-serrate, each serration tipped with two, or more, setae (u.m.). This diagnosis was made from one antenna and since then it has, unfortunately, been destroyed.

Hampson's figure (3) of *catena* female, which was figured from my type, is inexact and has not been drawn quite correctly by the artist. The post-medial series of hyaline spots of the fore-wing should be a little larger, and the fourth spot of the series, which is between veins 3 and 4, is missing. The basal, hyaline spot below the cell of hind-wing is also missing. The type-figure in the drawer of the B.M. Coll. shows the same defects. Probably this type-figure was figured from my type, and Hampson's plate-figure (3) was copied from the type-figure. Hampson's description (3) is more extended than my original one, but he omits (as also in his figure) the hyaline spot below the cell of hind-wing as there are three hyaline spots on the hind-wing. I have only one specimen, the female type from Garambi.

Eressa guttulata, Strand, and its aberration *trifenestrata*, may possibly be referable to *catena*. Strand compares *guttulata* with *subaurata*, Wlkr., and I herewith give a translation of his remarks. *Subaurata* is placed by Hampson one remove from *confinis*, Wlkr., and *catena* three removes from *confinis*.

" Allied to *E. subaurata*, Wlk., but the fore-wings are a little broader (but not so broad as in *E. confinis*). The spot behind the cell of the fore-wing is shorter and extends baseward only a little beyond the base of vein 2, is there broadly oblique and does not reach the middle of vein 2 towards the margin; the spot

in space 2 is just as long and acuminate towards the margin; the spot in cell is smaller, rounded or quadrate; the spots in the spaces 3-6 form an almost straight row, which is for the most part broadly separated from the other spots; the spot in space 5 of this row is always smaller and sometimes may be absent. Antennae bipectinate to a tolerable length. Hind-wings normal and also frons.

"Expanse of wings, 17–18; length of fore-wing, 9–10 mm.

"It is difficult to recognise the frenulum; in some cases, however, it is unmistakably divided, and I believe that all are ♀♀.

"Two specimens from Kankau are distinguishable by the presence of a very small, third spot behind the cell of hind-wing (ab. *trifenestrata* (Strd. n. ab.)."

Strand states that the antennae of *guttulata* are bipectinated to a tolerable length and that the frenulum is difficult to recognise, but that in some specimens it is obviously divided, and he believes that all [eleven specimens] are females. The unique type-female *catena* has the antennae minutely acuminate-serrate with two or more setae on each serration. If Strand's eleven specimens have bipectinate antennae they *might be males, rather than females*, and might possibly fit in as males of female *catena*. I only throw this out as a suggestion for the aid of future investigations. I think that ab. *trifenestrata* may be the same as *catena*. If this be so, then the name of *catena* would precede that of ab. *trifenestrata* and the first collective name *catena* would have priority for the species, which would then be known as *Eressa catena*, Wilem., whilst Strand's species would become *Eressa catena guttulata*.

I am unable to detect the frenulum in my female type *catena* even with the microscope.

Range :—

Wileman Coll. One sp. ♀ (type). Formosa (S.), Garambi, 1.x.1904.
Formosa only.
Regional range. Indo-Australian.

Type :—

Wileman Coll. *catena*. ♀. Formosa, Garambi.

Expanse :—20 mm. (tip to tip, 18 mm.).

17. **Eressa guttulata,** Strand.

Nom. Jap. *Unnamed.*
Eressa guttulata, Strand, Deutsch. Ent. Zeitschr., **1915**, H. i, p. 34, ? ♀ (1915) ? ♀, Formosa.
Eressa guttulata, Strand, ab. *trifenestrata*, Strand, Deutsch. Ent. Zeitschr., **1915**, H. i, p. 35, ? ♀ (1915) ? ♀, Formosa (= ? *catena* Wileman).

Antennae :—"Bipectinate" (Strand). Sex. ? ♂, ? or ♀.

I have not examined the type of *guttulata*, but hope to have the opportunity of doing so later on.*

For remarks and translation of Strand's original description see above, under *E. catena*.

Range :—

Deutsch. Ent. Inst. Berlin, 9 sps. ? ♀, Kankau (Kōshun) iv.;
"Sauter Ausbeute." 2 sps. ? ♀, Sokutsu (Banshōryō District) vi.
Formosa only.
Regional range. Indo-Australian.

Types :—

Deutsch. Ent. Inst. (Mus.). *guttulata.* ? ♀. *trifenestrata.* ? ♀. Formosa, Kankau (Kōshun).

* See Addenda, p. 451.

Time of Appearance :—iv, vi.
Expanse :—" 17–18 mm." (Strand). " Length of fore-wing, 9–10 mm." (Strand).

EUCHROMIA.

Hübner, Verz, bekannt. Schmett., p. 121 (1822); Hampson, Cat. Lep. Phal., i, p. 293 (1898).

18. **Euchromia elegantissima** (Wallengren).

Nom. Jap. *Beni-Kanoko-Ga* (15).
1. *Charidea elegantissima*, Wallengren, Eugenies Resa Omkr. Jord., p. 360, (0) (1861) (0', Manila (Jan.).
2. *Phalanna polymena*, Linné, Wallace et Moore (*error determinationis*, nec *P. polymena*, L.), Proc. Zool. Soc. Lond., p. 362 (1866) and also Semper (*error determinationis*, nec *P. polymena*, L.), Verh. Zool.-bot. Ges. Wien, 17, p. 701, No. 100 (1867) (larva).
3. *Euchromia orientalis*, Butler, Journ. Linn. Soc. Zool., 12, p. 364, (0) (1876) ♂, India (N.).
4. *Euchromia fraterna*, Butler, Journ. Linn. Soc. Zool., 12, p. 364, (0) (1876) ♂, Burma, Moulmein.
5. *Euchromia fraterna*, Btlr., Butler, Proc. Zool. Soc. Lond., p. 670 (1880) (amended descn.).
6. *Euchromia laura*, Butler, Journ. Linn. Soc. Zool., 12, p. 364, (0) (1876) ♀, East India.
7. *Euchromia siamensis*, Butler, Journ. Linn. Soc. Zool., 12, p. 365, (0) (1876) ♂, Siam.
8. *Euchromia formosana*, Butler, Trans. Ent. Soc. Lond., p. 114, pf. 4.7, (0) (1888) ♀, Formosa (= *elegantissima*).
9. *Euchromia orientalis*, Btlr., Butler, Trans. Ent. Soc. Lond., p. 114, pf. 4.6, (0) (1888). Type, N. India, ex err., *recte* Burma.
10. *Euchromia laura*, Btlr., Butler, Trans. Ent. Soc. Lond., p. 114, pf. 4.8, (0) (1888).
11. *Euchromia polymena*, L., subsp. *orientalis*, Btlr., Hampson, Cat. Lep. Phal., i, 298 (1898).
12. *Euchromia polymena*, L., subsp. *orientalis*, Btlr., ab. *formosana*, Btlr., Hampson, Cat. Lep. Phal., i, p. 298 (1898).
13. *Euchromia elegantissima*, Wllgrn., Semper, Reisen Philipp., 2, p. 424, No. 100, pf. K. 3–5 (1, p.), (1898) (larva).
14. *Euchromia elegantissima*, Wllgrn., var. *diffusihelvola*, Schultze (W.), Philipp Journ. Sci 3, i, A, p. 29, pf. 1.3, ♀ (1908) ♀, Philippines, Luzon, Manila.
15. *Euchromia polymena*, Linn., Matsumura (*error determinationis*, nec *E. polymena*, L.), Thousand Ins. Jap. (Zoku Nihon Senchū Zukai [J.T.]), Suppl., 3, p. 70, No. 617, pf. 35·21, ♀ (1911) N.J. *Beni-Kanoko-Ga*.
16. *Euchromia polymena*, Linn., var. *elegantissima*, Zerny in Junk's Lep. Cat., 7, p. 88 (25.vii.1912) (part).
17. *Euchromia polymena*, L., ab *laura*, Btlr., Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 85, pf. 12. *d*, (0) (1913).
18. *Euchromia polymena*, L., ab. *hainana*, Seitz, Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 85, pf. 12. *e*, ♂ ♀ (1913) ♂ ♀, Hainan I.
19. *Euchromia polymena*, L., ab. *egestosa*, Seitz, Seitz in Seitz's Gross. Schmett. [E. ed.], Ind.-Aust., 10, p. 85, pf. 12. *e*, (0) (1913) (0), Philippines.
20. *Charida* (*sic*) *elegantissima*, Wllgrn., Hampson, Cat. Lep. Phal., Suppl., i, p. 197, No. 656 (1914).
21. *Euchromia orientalis*, Btlr., Strand, Deutsch. Ent. Zeitschr., **1915**, H. i, p. 35 (1915) (= *elegantissima*).
22. *Euchromia orientalis*, Btlr., ab. *burmana*, Strand, Deutsch, Ent. Zeitschr., **1915**, H. i, p. 35, ♂ (1915) (= ab. 2 ♂, Hampson, 11, p. 298).

Antennae :—Male. " Shaft slightly dilated at middle, bipectinate, with moderate branches dilated at extremity " (Hampson).
Female. Same.

Wallengren (1) states that he considers *elegantissima* a distinct species. " *Charid polymenae* affinis, sed re vera distincta species." Hampson at first separated *E. polymena orientalis* as subspecies 2 (11), and then afterwards made *orientalis* into a species determining it as *elegantissima*, which has priority (20).

Strand says (21): " None of the seven specimens which lie before me belongs to the ab. *formosana*, Butler, which probably occurs in Formosa, as elsewhere, as a genuine aberration . . . it is almost a matter of taste whether one includes

this form [*Euchromia orientalis* = *elegantissima*] as a subspecies of *E. polymena*, L., or as a good species."

I would remark, however, that, when one comes to examine the series of fifty-five specimens of *elegantissima* and forty-one of *polymena*, as arranged in the B.M. Coll., one sees that the crimson abdominal bands are constant in number, but not always in colour, in *each* species, viz. in *polymena* (excluding the basal band in each), two crimson (or yellow) bands on the fourth and fifth segments, and, in *elegantissima*, three crimson bands, on the fourth, fifth and sixth segments, sometimes crimson mixed with orange. It is to be noted that Butler's type of *formosana* (8) from Formosa, which Hampson calls ab. 1. *formosana* (12), is only a chance aberration, as none of the other eleven specimens from Formosa in B.M. and Wileman Colls., which are referable to *elegantissima* (= *orientalis*) has the "fore-wing with the two orange patches below the cell conjoined though more or less indented by spots" (12). *Formosana* is an example of an abnormal form being selected for the type instead of the more normal form. There are only four specimens of this abnormal form amongst the fifty-five specimens of *elegantissima* in the B.M. Coll. One from Formosa (type) and three from Burma. *Elegantissima* is therefore the form actually predominant in Formosa, *not formosana*, which is merely an aberration. Seitz observes (17, p. 85) that *elegantissima* is "the common form in the Philippines, resembles a large spotted *orientalis* but has the first segment orange." Butler's male type of *orientalis* has the basal semi-band (= first segment) orange, tinged moderately with crimson scales as in Formosan *elegantissima*. In the series of fifty-five *elegantissima* these red scales as a rule predominate over the yellow ones. Only in the case of the one specimen of ab. *burmana* (22) is this semi-band entirely yellow. My Japanese collector met with *elegantissima* freely in the extreme south of Formosa, at Garambi (where it links up with that species in Luzon Island, Philippines, more to the south), but it seems to be scarcer further north in Formosa.

Butler remarks that "the type of *fraterna* unfortunately was labelled 'N. India'—doubtless an error, as the species has since come in some numbers from Burmah," and he gives an amended description of the type (5). The crimson abdominal bands of Matsumura's figure (15) are not very clear, but seem to represent those of *elegantissima*, and in the Japanese text he says that the figure has crimson bands on the basal, abdominal segment and on segments four, five and six. The locality given as Arizan, Formosa, seems a high altitude for its habitat (*circa* ? 5,000–7,000 feet). In the B.M. and Wileman Colls. there are *no* true *polymena* from Formosa. *Hainana* and *egestosa*, new aberrations described by Seitz (18, 19), are evidently referable to *elegantissima*. Hampson's reference for *Euchromia polymena*, L., is Cat. Lep. Phal., i, p. 297, tf. 137 ♂ 1898), and Seitz's figure pf. 12. *d*, (0) (17, p. 85). Moore's reference for the larva of *polymena* is Lep. Ceylon, 2, p. 39, pf. 94.6–6*a* (1882); "it feeds on *Convolvulaceae*, Thwaites."

Semper describes and figures the larva of *elegantissima* which, at Manila, Luzon I., Philippines, feeds on *Convolvulus pescaproe* (*pie de cobra*). He also records as a separate species (13, p. 425, No. 101) *E. polymena* from Negros and Cebu Islands, Philippines; his larva figure (13) refers to *elegantissima*, but it resembles very much the larva of *E. polymena* figured by Moore (*supra*).

Strand names "Ab. 2," ♂, from Lower Burma, mentioned by Hampson in Cat. Lep. Phal. (11) as *burmana* (22). Zerny (16) places *elegantissima* and all other forms under *polymena*, and it is not improbable that *elegantissima* may eventually be sunk to the latter.

Range of E. elegantissima (*orientalis*) :—
B.M. Coll. Formosa. 9 sps. 6 ♂♂, 3 ♀♀.
Garambi (x, Wileman); Kagi (viii, Wileman); Takow (type *formosana*) (Hobson); one unlocalised.
Philippines. 8 sps. 3 ♂♂, 5 ♀♀.
Luzon I., Manila (xii, Walker); Mt. Limay (Baker); ? Luzon, Taytai (i, Betton).
Wileman Coll. Formosa. 3 sps. 2 ♂♂, 1 ♀,
Garambi (x).
Philippines. 1 ♀.
Luzon I., Rizal prov., Manila (iii).
Deutsch. Ent. Inst. (Mus.). Berlin, "Sauter Ausbeute."
Formosa. 7 sps. Tainan; Kankau (Kōshun); and "Formosa."
Formosa (11, 15); Philippines (10), and Babuyanes Is., Luzon I., Mindoro I. (Semper, 13); Borneo (11); Burma (11); India (N.) (10); Penang (10); Singapore (10); Siam (10); Java (M.C. Vind. 16).
Regional range. Indo-Australian.
Time of Appearance :—Formosa. viii–x.
Philippines. x–iv (Semper).

Types :—

? Royal Swedish Scientific Acad.	*elegantissima.*	(0).	Philippines, Luzon, Manila.
B.M. Coll.	*burmana.*	♂.	Lower Burma, Pegu = "ab. 2," Hampson.
	formosana.	♀.	Formosa.
	fraterna.	♂.	Burma, Moulmein.
	laura.	♀.	India.
	orientalis.	♂.	India (N.)? ex err.; *recte* Burma.
	siamensis.	♂.	Siam.
Bureau of Science, Manila.	*diffusihelvola.*	♂♀.	Philippines, Luzon, Manila, xii, No. 448.
Senckenberg Mus. Frankfort-on-Main.	*egestosa.*	(0).	Philippines.
Where?	*hainana.*	(0).	Hainan Island.

Expanse :—Formosan specimens only. 50–44 mm. (tip to tip, 47–42 mm.) (B.M. and Wileman Colls.). "Length of wing. ♂, 19–22 mm., ♀ 21–23 mm." (from 171 specimens from Babuyanes Is., Luzon I., and Mindoro (Semper)).

Doubtful Formosan Species.

Ceryx diptera, Fabricius.

1. *Zygaena diptera*, Fabricius, Syst. Ent. p. 555 (1775).
2. *Syntomis atereus*, Cramer, Wallace et Moore, Proc. Zool. Soc. Lond., p. 362 (1866).
3. *Ceryx diptera*, Fabr., Hampson, Cat. Lep. Phal., i, p. 36, No. 14, tf. 15, ♂ (16.xii.1898).

Wallace and Moore (2) recorded *S. atereus*, Cramer, from Formosa in their "List of Lepidopterous Insects collected at Takow, Formosa, by Mr. Robert Swinhoe." The collection made by Swinhoe was handed over by him to Wallace and Moore for determination. No specimens of *atereus* seem to have been recorded by any authors from Formosa, and there are no Formosan specimens in

the B.M. and Wileman Collections. The range of *atereus* (sunk by Hampson to *diptera*) is, according to the series in the B.M. Collection and also Hampson (3, p. 37), confined to India and Ceylon. Moore seems to have determined the specimen, or specimens, cited by him as *atereus* (2, p. 362). This may be a misdetermination, and it is not possible to trace Moore's specimen.

Addenda.

P. 444. Insert as No. 9*a* in the citations the following:—

9*a*. *Syntomis erebina*, Butler, Matsumura, Cat. Ins. Jap. (Nihon Konchū Sōmokuroku [J.E.T.]), 1, p. 170, No. 1439 (21.viii.1905). N.J. *Hime-Kanoko*. This Japanese name sinks to that of *Kanoko-Ga*, which has priority.

P. 447. I have received and examined the cotype of *Eressa guttulata*, Strand (Kankau (Kōshun) Formosa, H. Sauter, viii.1912), and the cotype of *Eressa guttulata*, Strand, ab. *trifenestrata*, Strand (Kankau (Kōshun) Formosa, H. Sauter, iv.1912), both referred to on p. 447. Microscopical examination determines them both as males. Cotype male ab. *trifenestrata*, is evidently the male of type female *Eressa catena*, Wileman (p. 446), which has priority. Cotype male *Eressa guttulata*, Strand, sinks to *Eressa catena*, Wileman, as a variety or aberration.

Antenna:—Type male *Eressa guttulata trifenestrata*, Strand. Pectinate, with moderately thick, short pectens which are apically tipped with one, long, curved seta (u.m.).

The frenulum of type female *catena* is *visible*. (Cf. p. 447.)

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FORMOSAN SYNTOMIDÆ.

THE RHOPALOCERA OF THE "ST. GEORGE" EXPEDITION, FROM FRENCH OCEANIA

By Prof. E. B. Poulton, F.R.S., and N. D. Riley.

[Read June 6th, 1928.]

With Plate XXI (Figs. 12 and 13 only) and Two Text-figures.

The following list is based upon the collections made by the "St. George" Expedition to the South Pacific Islands in 1924–1925, now in the British Museum collection, and by Miss Cheesman in 1925 in the Society Islands. These have been supplemented to some extent by material in the British Museum derived from other sources. Prof. Poulton is responsible for the accounts of *D. plexippus*, *E. eleutho* and *H. bolina*, and Riley for the remainder of the Rhopalocera. Mr. Collenette, who, with Miss Longfield, collected the Lepidoptera obtained during the "St. George" Expedition, has very kindly added a number of field notes.

There still remains much work to be done in the part of the world concerned. If the authorities of other national museums were able to supplement this list from their collections, it would be of immense value in determining the remaining species, and would give us a more comprehensive knowledge of the insect fauna of the South Pacific.

That our present records are very incomplete is clearly shown in the recent issue of Schröder's *Handbuch der Entomologie* in which the number of species of Lepidoptera recorded from these groups is given as 13, while the present list, together with those by Mr. Collenette and Mr. Meyrick, dealing with three families of Heterocera and the Microlepidoptera respectively, which will be found printed immediately after, already enumerates 126.

The types are in the British Museum.

Danaida plexippus, Linn.

Papilio plexippus, Linn., Syst. Nat., Ed. X, p. 471, 1758.

Marquesas.

Fatu Hiva, 5–7.i.25. 7 ♂, 1 ♀. All labelled sea-level.
Hiva Oa, Atouana, 4.ii.25. 1 ♂.

The species was observed to be fairly common on Fatu Hiva, but so rare on Hiva Oa that the single male recorded above was the only specimen identified with certainty. No examples were seen on Nuka Hiva or Tahuata.

The great interest of these specimens, which are of the well-known type of the migrant *plexippus*, lies in the important contribution which they afford to the history of this butterfly in the Pacific Islands, fortunately recorded in its earlier period by Commander J. J. Walker (*E.M.M.*, vol. xxii, 1885, pp. 217–224; vol. l, 1914, pp. 181–193, 224–237); in its later by Mr. C. L. Collenette (*ibid.*, vol. lxi, 1925, pp. 198–202). Commander Walker's two papers record the earliest observed appearance of *plexippus* and its food-plant, *Asclepias curassavica*, in the various islands, their increase and apparent establishment, except in New Caledonia, where both plant and insect suffered a decrease

between 1881 and 1900 (*ibid.*, vol. l, p. 190). Mr. Collenette's paper shows that on the visit of the "St. George" in 1925 the butterfly was not seen on three islands in which Commander Walker found it commonly or plentifully in 1883. On one island (Fatu Hiva) it was fairly common in both years, on one (Hiva Oa) abundant in 1883, almost absent in 1925. Finally, on two islands where it was seen in 1883 neither the insect nor the food-plant could be found in 1925.

Mr. Collenette concludes that "the present scarcity of the butterfly on these islands is due to the dying out of its food supply. It arrived in the wake of the *Asclepias*, and it is suffering a temporary or permanent reverse with the disappearance of the plant" (*ibid.*, vol. lxi, p. 202). The cause of this disappearance is at present uncertain.

The want of uniformity in the use of the names *plexippus*, L., and *archippus*, F., having caused some inconvenience, I append below, with his kind consent, an interesting note on the subject drawn up by my friend Mr. N. D. Riley.

Linné's original description of *Papilio plexippus* (*Syst. Nat.*, Ed. X, p. 471) applies equally well to either the N. American Monarch butterfly or the Oriental species subsequently described as *P. genutia* by Cramer. But the locality is given as N. America, and the authorities quoted all refer only to New World species. Were it not for the fact that right at the end of his remarks Linné added: "fore-wings with a white fascia as in the next species [*chrysippus*] which it resembles," there could be no claimant for the name other than an American species. It is important to note that in his original description Linné makes no reference to any specimen in the *Mus. Ludov. Ulric.*; and, as he was most careful throughout the *Syst. Nat.* to give such references, it may be assumed that the original description is based either upon the earlier quoted figures or upon a specimen in Linné's own collection, which would be the type, and not upon any specimen that may or may not have been in the *Mus. Ludov. Ulric.* This is important because in *Mus. Ludov. Ulric.*, p. 262, as shown by Aurivillius, Linné added "China" as a locality and so amended the original description that it applied to the Oriental species almost to the exclusion of the Monarch.*

As Dr. Verity has shown (*J. Linn. Soc. Zool.*, xxxii, p. 173, 1913), with a little practice it is possible to recognise from among the mass of specimens that now compose the "Linnean collection" preserved at the Linnean Society's rooms in Piccadilly those specimens that were without doubt Linnean, in spite of the great additions made by Smith. Of the species involved in this discussion there are now 5 specimens in this collection, and I have no hesitation in saying that the only Linnean specimen is a solitary male of the N. American Monarch. It bears a label in Smith's writing "archippus Fab." On the other hand, one of the 4 non-Linnean specimens bears a label also in Smith's handwriting "plexippus," and, stranger still, a second label in Linné's own writing "80 plexippus"! (80 is the number of the species in *Syst. Nat.*, Ed. X). Linné could not have put this label on a specimen he never possessed. It is notorious that Smith extensively altered the Linnean collection from its original state, making additions, changing names and even from time to time giving away parts of it in exchange. It is justifiable therefore, I consider, to assume that Smith, when Fabricius had forced the adoption of the name in the later

* In the same publication (*Kongl. Vet. Akad. Handling.*, xix (5), pp. 1–188, 1882) Aurivillius clearly shows that Linné's earliest extant description of *plexippus* (in MS.) refers *only* to the Monarch of N. America.

(*Mus. Ludov. Ulric.*) sense, merely transferred the Linnean label from the real type specimen to one of his own specimens, so as to "keep the collection up to date." The species is marked with an underscore in Linné's annotated copy of the 10th edition, indicating that it was represented in his collection. It is not underscored in his annotated copy of the 12th edition (*see* Jackson, Cat. Linn. Specimens, *Proc. Linn. Soc.*, Suppl. 1913).—N. D. R.

Euploea eleutho walkeri, H. H. Druce.

Nipara helcita walkeri, H. H. Druce, E.M.M. (2), i, p. 320.
Euploea helcita walkeri, Poulton, Trans. Ent. Soc. Lond., 1923, p. 582 (1924).
Euploea helcita matilica, Fruhstorfer, in Seitz, vol. ix, p. 276.

Talbot (*Bull. Hill Mus.*, i, p. 26) suggested, and Hopkins has since shown (*Insects of Samoa*, Pt. III, fasc. 1, p. 11, 1927) that *E. helcita* and *E. eleutho* are to be considered as one species. Collenette writes: "At Tahiti, fairly common in February and March, 1925, at sea-level and in the hills."

Society Islands.

The specimens of this race of *eleutho*, taken on the "St. George" Expedition, resemble those hitherto received and originally described from the Society Group. The detailed and accurate data, however, reveal an interesting sex-relationship, as shown in the following table:—

Date of capture in 1925.	Locality.	Number and sex.	Condition of Tahiti specimens.
February 21	Tahiti: Papeete.	2 ♂.	Four fairly fresh, but two of them rather chipped; 1 worn.
,, 22	,, ,,	1 ♂.	
,, 23	,, ,,	2 ♂.	
,, 25	,, ,,	1 ♂, 1 ♀.	♂ like above two; ♀ very worn.
,, 28	,, ,,	2 ♂.	Two fresh, but injury to R.H.W. of one; 2 fairly fresh, but chipped; 1 worn; 3 very worn.
March 3	,, Fautaua Valley: 500 ft.	5 ♂.	
,, 5	,, Papeete.	1 ♂.	
,, 11	,, Fautaua Valley: 1500 ft.	2 ♀.	Eight fairly fresh, but chipped; 1 worn; 2 very worn.
,, 11	,, Fautaua Valley: 2000 ft.	9 ♀.	
,, 11	,, Fautaua Valley: 2500 ft.	4 ♀.	Three fairly fresh, but chipped; 1 very worn.
,, 17	,, Fautaua Valley: sea-level to 500 ft.	1 ♀.	Worn.
,, 13	Moorea: sea-level.	2 ♂.	

Thus among 16 specimens taken at Papeete, near sea-level, and in the Fautaua Valley up to 500 ft., there are only two females, while among the 15 specimens taken in the Fautaua Valley between 1500 and 2500 ft. there is not a single

male. The condition of the specimens is not markedly different. The striking difference between the sexes from the low and high elevations may be merely accidental, or due to the early emergences of the lower and warmer horizon corresponding in time with the later emergences of the higher and cooler. It is possible, however, that they are the outcome of an adaptation which tends to prevent interbreeding between the members of the same family. The data on the female taken 17 March, 1925, being incomplete, I wrote to Mr. Collenette, who, in kindly supplying the information, added the interesting notes quoted in the following paragraphs :—

" 14 April, 1928. The data for the insects on March 17 should be ' Fautaua Valley, sea-level to 500 ft.' On that day we ran into rain before reaching the base of Fautaua Fall, and therefore probably collected nothing above 250 ft. (which would be borne out by the absence of a height figure on the labels), but I cannot limit the figure definitely to the latter.

" It is exceedingly interesting that the males of *Euploea walkeri* were mainly at low elevation and the females at a high elevation, as this bears some resemblance to the notes on the Tahitian *bolina* (p. 460). It is a great pity that we did not collect more of the *Euploea*, but we thought that so many had been brought home previously, and the form was so constant, that they would be of little interest.

" Possibly some more definite data for the ' near sea-level ' Euploeas would be of interest, and I append notes for the days on which they were taken :—

" 21/2/25. Gardens, waste ground, Lantana, etc., at back of Papeete town. Afternoon. Sunny, dull later.
" 22/2/25. Gardens, waste ground, Lantana. Whole day. Steady rain.
" 23/2/25. Gardens, waste ground, Lantana. Morning. Sunny.
" 25/2/25. Small stream at back of town. Mainly secondary growth. Lantana, etc. Morning. Sunny.
" 28/2/25. Coast road for 3 miles to S.W. of town. Afternoon. Cloudy.
" 5/3/25. Small stream as on 25th. Sunny, with heavy rain later."

[**Euploea orope,** Boisd.]

Euploea orope, Boisd., Voy. " Astrolabe," Lep., p. 100, 1832.

Boisduval's description is based upon specimens supposed to have come from Tahiti. His figure is of a common *Euploea* of Timor (cf. Fruhstorfer in Seitz, ix, p. 241).

[**Hamadryas zoilus,** Fab.]

Papilio zoilus, Fab., Syst. Ent., p. 480, 1775.

Boisduval (Voy. " Astrolabe," Lep.) records this species from Tahiti. Apparently it has never been met with since in that island, nor, in fact, anywhere east of the Solomons. No doubt the record is due to an error of labelling. Boisduval himself complains in his preface that the authorities of the Paris Museum had caused a great deal of confusion in handling the collections brought back by the " Astrolabe."

Libythea collenettei, sp. nov.

(Plate XXI, fig. 13.)

♀. *Upperside,* both wings antique brown (Ridgway's *Color Standards,* Pl. III) marked with blackish-brown. *Fore-wing* costal margin between costa and cell, veins in proximal half, apex rather broadly and termen less broadly and irregularly, blackish brown; an

oblong spot of the same colour beyond cell-end, but not fully occupying the base of area 4, is connected with the costal dark area on the one side and a projection of the terminal border along vein 4 on the other side, thus forming an irregular diagonal subapical band. *Hind-wing* anteriorly occupied by a semicircular blackish-brown area (centrally filled in by the ground-colour), the hind edge of which runs along lower edge of cell and thence curves up towards apex; areas 1*a*, 1*b* and 1*c* mostly blackish-brown, shading in 1*c* into the ground-colour about midway; margin blackish-brown, diffusely and broadly at anal angle, thence less so to vein 6, where it suddenly widens again.

Underside, fore-wing ground-colour as above, the diagonal subapical band barely indicated by darker, the costa and terminal border of same shape as above, less dark, heavily irrorated with pale grey scales. *Hind-wing* of same colour as marginal areas of fore-wing, basally paler due to very dense irroration of pale grey scales, bearing numerous short dark transverse striae and with a narrow chain-like band of paler spots running from apex at vein 7 in a straight line to vein 3 and, in one specimen only, continued thence indistinctly in a gentle curve almost to anal angle.

Head, thorax, abdomen and palpi above blackish-brown, below pale grey. Legs proximally grey, distally dark brown ringed with pale grey. Second segment of palp rather densely hairy. Antennae deep reddish-brown, blackish above, only slightly thickened distally towards the small compressed club.

Length of fore-wing, 19–20 mm.

Habitat. Marquesas, Nuka Hiva, 18.i.25 (*C. L. Collenette*).

Three specimens only were captured, all females. The species had been observed previously, however, by Commander J. J. Walker, who has very kindly supplied the following extract from his Journal:—

"14th March, 1883. At Taa-hu-ku, South side of Hiva Oa (Dominica), Marquesas Is.—I also saw another butterfly, a small fulvous fellow, I fancy the same as a *Phyciodes*? ? [*Atella gaberti*, Guér.] which is common at Tahiti, from which island I have a pair: this one was flying high in an awkward place, so I did not get near enough to catch it."

Mr. Collenette's notes on this remarkable find run as follows:—

"Three specimens taken and two or three others seen in the Hooumi Valley, Nuka Hiva Island, Marquesas, on 18.i.25. They frequented a stream-bed near sea-level. They were attracted by some flowering plants growing in the water, but flew round them only a few seconds at each visit, settling very rarely. On 16.i.25, 5 or 6 specimens were seen, on a ridge above the Typee Valley, at about 1200 ft. They flew against the wind, fairly rapidly and without settling. A considerable search was made for the insect on other days, especially in the hills, but no others were seen. In flight they were often confused with the introduced *Polistes* wasp, the speed of flight and apparent size being much the same, although I do not think that this was a definite example of mimicry."
—C. L. C.

Libythea geoffroyi, which approaches this species geographically more nearly than any other, bears very little general resemblance to it. In the details of the pattern of the upperside *L. collenettei* is nearest the European *L. celtis*; in superficial appearance nearest the American *L. terena* from Cuba and Haiti. In the outline of the fore-wings it is unique in the genus on account of the almost entire absence of any projection of the termen about vein 5. The length of the palpi in relation to that of the antennae is less than in any

other species in the genus, less even than in *L. geoffroyi*, which in this respect approaches it most closely.

It is very remarkable and unexpected that this endemic and most distinct species of an admittedly very old and widely distributed genus should be met with on this single remote and isolated island in the Marquesas. One would like to assume from the simple structure of the insect as compared with the other members of the genus that it is a survival of older stock. Possibly it might be explained by assuming that the Marquesas are the remnants of some old and extensive land mass and that *L. collenettei* is a survival from the fauna of that once larger area, persisting in the Marquesas because of some unknown favourable condition. It has, indeed, been pointed out that certain geological features of the Marquesas contrast very strongly with those of the Society Islands and suggest a somewhat different origin.

Atella gaberti, Guérin-Méneville.

Melitaea gabertii, Guérin, Voy. "Coq.," pl. 16 (1829), p. 277 (1838).
Atella gabertii, Butler, P.Z.S., 1874, p. 283; Fruhst. in Seitz, ix, p. 475.

Society Islands.

Tahiti:—Val de St. Amelie, 3000 ft., 5.v.25. 1 ♂. L.E.C.
Fautaua Valley, 500–2500 ft., 3–11.iii.25. 5 ♂, 8 ♀. C.L.C.
Papeete, 24.ii.25 (7 p.m. at light!). 1 ♀. C.L.C.
Papenoo, iii.25. 1 ♀. L.E.C.
Tautira, Vaitepiha Valley, 11.viii.25. 1 ♀. L.E.C.
Moorea:—Sea-level, 12.iii.25. 2 ♀. C.L.C.

Males appear to be much rarer than females in this species. The above records give 6 males to 11 females from Tahiti; 2 females only from Moorea. Specimens previously received at various times by the British Museum gave the proportions of 2 males to 12 females, an even greater disparity. The explanation is probably to be found in the occupation of different flight zones by the two sexes, and not in an actual numerical superiority of the females such as exists in *Hypolimnas bolina* upon some of the S. Pacific islands. All the Tahitian females taken by the "St. George" Expedition and by Miss Cheesman were found between 500 and 1500 ft. altitude; of the males only 2 were taken in this zone, the other 4 all having been found at altitudes of 2000–3000 ft.

"Fairly common at sea-level and in the town of Papeete, where it usually flew at some height from the ground and was difficult to catch. Quite common from 500 to 2500 ft., frequenting Lantana blossoms, on which it was easy to net. Commonly seen in flight in the late afternoon, up to 5 p.m., when other butterflies had retired for the night. One came to light at 7 p.m., probably disturbed from herbage."—C. L. C.

Precis villida longfieldae, ssp. nov.

(Plate XXI, fig. 12.)

Tuamotus.

Disappointment Islands:—Napuka, 8.ii.25. 12 ♂, 9 ♀.

In Seitz, vol. ix, p. 522, Fruhstorfer adopts Seitz's MS. name *taitica* for "on the upperside conspicuously pale and extensively red-coloured examples, such as lie before me from the Marquesas and similarly from Fiji." On the

evidence of the material in the B.M. Fijian and Tahitian specimens are quite inseparable from examples from Tongatabu (= Amsterdam Is.), the type locality (the type ♂ of *villida*, F., is in the B.M.). In what form the species flies in the Marquesas, as alleged by Fruhstorfer (*l.c.*), is not known. In any case it would be a pity to restrict the name, considering its implications, to a race not found in Tahiti. Although Fruhstorfer makes no mention of having specimens from that island, it would appear best to restrict the name to the *villida* inhabiting it, in which case it becomes a synonym of *P. villida villida* unless subsequently it should appear that the Tahitian population differs from that of Tongatabu.

The specimens collected by the "St. George" Expedition in Napuka differ markedly from *P. villida villida* from Tongatabu, Fiji and Tahiti, and may be known as *P. villida longfieldae*, ssp. nov.:

♂. *Upperside* differs from that of *P. v. villida* in having the row of pale spots (in areas 4, 5 and 6) of fore-wing relatively much smaller, and, as often as not, completely included within the outer edges of the basal black area. There is no pale spot basally in area 3. On the *underside* the dark markings are all more intense than in *P. v. villida*, the surface presenting much greater contrasts in the distribution of colours. The basal two-thirds of the hind-wing are definitely greyish in tone, completely devoid of red or orange markings; and the usual dark shade outwardly bordering this area is both wide and very dark. The submarginal red shading is restricted almost entirely to the neighbourhood of the anal ocellus.

♀. On the *upperside* shows a corresponding diminution of the size of the pale spots in areas 4–6, and on the underside a corresponding darkening. The grey basal area is, however, not entirely free of orange markings, nor are these excluded from the anterior ocellus in the submarginal area of the hind-wing; but in both areas they are very faint.

Length of fore-wing, ♂, 18–21 mm.; ♀, 19–21·5 mm.

It will be seen from the measurements that this race is on the whole smaller than any other known. It is curious that of the nine females captured two have malformed right fore-wings. In one case there is a shortening of the costal, in the other of the inner margin.

"Moderately common, flying closely over the low-growing vegetation with an uncertain and sometimes swift flight, and frequently settling on leaves and lumps of coral in the sun. The prevailing trade wind is from the east, and the *Precis*, which probably arrived from or via Tahiti, must therefore have come to this isolated island against the wind.

"At Fakarava (Tuamotus), where conditions appeared very similar to those on Napuka, the botanical collections from the two islands being almost identical, the *Precis* was not seen. Fruhstorfer (Seitz, p. 522) records this species from the Marquesas. Neither Commander Walker nor the 'St. George' Expedition met with it there, and it would be interesting to know if the record is well authenticated."—C. L. C.

Melanitis leda solandra, Fab.

Papilio solandra, F., Syst. Ent., p. 500, 1775. *Cyllo leda* var. *taitensis*, Felder, Verh. z.-b. Ges. Wien, xii, p. 493, 1862.
Melanitis leda solandra, Fruhst., in Seitz, ix, p. 363, 1911.

Society Islands.

Tahiti:—Val de St. Amelie, 2000 ft., 5–6.v.25. 2 ♂. L.E.C.
Papenoo, iii.25. 1 ♂. L.E.C.
Fautaua Valley, 2000 ft., 3–17.iii.25. 4 ♂, 5 ♀. C.L.C.

All specimens are of the wet-season form, with very well-developed ocelli. Specimens from the Tonga Islands are inseparable from them, but Samoan examples, though referred by Hopkins to the same subspecies, are in my opinon sufficiently distinct to deserve a name. They may be known as **Melanitis leda hopkinsi**, ssp. nov. :—

♂. *Upperside* rich warm brown, the postdiscal orange area of fore-wing not prominent, sometimes barely distinguishable, white dot in area 4 small, indistinct or absent, ocelli of hind-wing areas 2 and 3 very small or absent, that in area 3 being the more frequently missing. *Underside* redder than in Tahitian examples, with smaller and less prominent ocelli, that in area 4 noticeably smaller than the one in area 3.

All Samoan specimens that I have seen can readily be separated from Tongan and Tahitian specimens by their generally dingier and more unicolorous appearance.

"Not rare in the hills, between 500 and 2500 ft., and chiefly met with under avocado pear and mango trees, to which they were attracted by the rotting fruit. Of 8 specimens noted at rest on different occasions, all in deep shade under trees, 7 were in an upright position, while one leaned to the left at an angle of about 45 degrees."—C. L. C.

Hypolimnas bolina, Linn.

Papilio bolina, Linn., Syst. Nat., Ed. X, p. 479, 1758.
Diadema auge var. *otaheitae*, Felder, Verh. z.-b. Ges. Wien, xii, p. 492, 1862.
Diadema otaheitae, Butler, P.Z.S., p. 281, 1874.

Society Islands.

Tahiti:—Papeete, near sea-level (p. 456), 21 & 23.ii.25. 10 ♂.
Fautaua Valley, 500–1500 ft., 3.iii.25. 6 ♂.
„ „ 1500 ft., 11.iii.25. 2 ♂.

The single male taken 21.ii.25 and two of those taken 23.ii.25 exhibit the characteristic symmetrical injuries to the hind-wings which have been observed to be inflicted by birds, as described in *Proc. Ent. Soc. Lond.*, vol. ii, 1927, p. 11.

Although no females were present, Mr. C. L. Collenette, in his interesting paper (*E.M.M.*, vol. lxii, 1926, p. 25) states that they were seen, and that their relative numbers appeared to be much smaller (3 ♀ to 200–300 ♂) at the lower elevation—0 to 500 ft., than at the higher—500 to 1500 ft., where the proportion appeared to be 1 ♀ to 3–5 ♂. The better condition of *bolina* at the higher elevation and the more strongly marked whitish band on the male under surface suggest, he considers, that the specimens were of a later brood.

In estimating the proportion of the sexes, it must be remembered that the females in Tahiti are very male-like. Thus Mr. H. W. Simmonds wrote, 19.iv.1920, from this island—"There seem to be hundreds of males to one female. I say 'seem to be' because the two (now four) females I have taken are almost like the ♂, and, as all are worn, I may pass them by" (*Proc. Ent. Soc.*, 1920, p. lxxii). This inference "was justified later on when Mr. Simmonds bred in Tahiti twenty-two males and twenty females from the mixed larvae of five female parents" (*ibid.*, 1923, p. xi).

Moorea, near sea-level, 11–13.iii.1925. 15 ♂.
500 ft., 12.iii.1925. 1 ♂.

Only two females were seen (*E.M.M.*, vol. lxii, 1926, p. 26).

MARQUESAS.

Hiva Oa, no elevation stated; probably near sea-level, 27–29.xii.24. 2 ♂, 3 ♀ (*a*, *b*,
" " 1000 ft., 30.xii.24. 3 ♂.
" " no elevation stated; probably near sea-level, 31.xii.24. 3 ♂.
" " 1500 ft., 31.xii.24–1.i.25. 1 ♂, 1 ♀ (*d*).
" " Atouana, 300 ft., 1.i.25. 1 ♂, 1 ♀ (*e*).
" " 1200 ft., 2.i.25. 1 ♂, 1 ♀ (*f*).
" " no elevation stated; probably near sea-level, 3.i.25. 1 ♂.

Mr. Collenette states (*ibid.*, p. 25) that *bolina* "was fairly common at lower levels, but in poor condition. Between 1000 and 2000 ft. it occurred in smaller numbers but in better condition." The males appeared "to outnumber the females by about five to one."

Female *a* bears the distinct impress of a bird's beak on the right fore-wing.

Fatu Hiva, sea-level (*ibid.*, p. 25), 5–7.i.25. 3 ♂.

"Males in small numbers at sea-level, in very poor condition. None were seen inland, and no females were noted" (p. 25).

Tahuata, 500 ft. on one ♂, others probably near sea-level, 10.i.25. 5 ♂, 1 ♀ (*g*).
" probably near sea-level, 11.i.25. 1 ♀ (*h*).
" " " " 14.i.25. 1 ♂.

"In small numbers, commoner near the coast than inland. . . . Males outnumbered the females by perhaps seven to one" (p. 25).

Nuka Hiva, Typee, probably near sea-level, 16–18.i.25. 7 ♂, 1 ♀ (*i*).

"Fairly frequent, but not seen above 1500 ft. . . . About ten males were seen to one female" (p. 25).

A male taken 16.i.25 bears the same evidence of bird attack as that borne by the three Tahiti males (p. 460).

The nine Marquesas females are extremely interesting, because they can be compared with five others from the same island taken by Commander Walker in 1883.

The "St. George" females appear to be forms of *thomsoni*, Butl. (= *moseleyi*, Butl.), with less blue on the hind-wing than the type, and in most of them a far stronger marginal pattern and a trace of the "*nerina* red" * in the fore-wing. This latter marking, not of a red but an orange tint, is just visible in five females (*b*, *e*, *f*, *g*, *h*) and conspicuous in *d*. The marginal pattern of both wings is distinct and conspicuous in *a*, *b*, *h*, *i*, of a pale ochreous (varying in depth of shade), becoming lighter and spreading at the apex of fore-wing in all except *b*. The marginal pattern is duller and much less prominent in *c*, *d*, *e*, *g*, and barely visible in *f*, although distinctly developed at the fore-wing apex of this female as well as *c* and *e*. Looked at from in front, with the observer's back to a good light, a distinct blue mirror is seen on the hind-wings of all except *g*, being least developed in *b* and *h*. Opaque blue scales border the mirror on its outer side in *b*, *c*, *d*, *e*, and *f*.

* For this F.W. marking and a classification of Pacific female forms, see *Trans. Ent. Soc. Lond.*, 1923, pp. 652, 653.

In spite of these differences in detail (of which the most obvious are those in the marginal patterns) the appearance of the series is remarkably uniform—at least for such a protean form as the female *bolina* in the Pacific.

Of the five females taken 10–11.iii.1883 in Fatu Hiva by Commander Walker, one in the Hope Department and one in the British Museum resemble *d*, the most brightly marked (except as regards the marginal pattern) of the "St. George" Marquesas females, but are even brighter with a more strongly marked "*nerina* red," hind-wing blue, and apical orange. They might, in fact, be considered forms of the *nerina*-like female *elliciana*, Fruhst. In the three remaining females, the marginal pattern of hind-wing is evanescent; the apical orange of two is as in the Oxford specimen, but there is only a faint trace of "*nerina*-red" in one and none in the other, with a very slight indication of hind-wing blue in both. The third female has the apical orange much reduced but with the "*nerina*-red" nearly and the hind-wing blue quite equal to the Oxford specimen.

Thus these five females are on the whole more brightly coloured and strongly marked than the "St. George" series of nine, captured more than forty years later. It is unfortunate that all the five came from Fatu Hiva, where no females were seen in 1925.

Southern Islands.

Rapa:—11–15.iv.25. 4 ♂, 4 ♀ (*j*, *k*, *l*, *m*, the last fresh).
,, 17.iv.25. 4 ♂, 6 ♀ (*n*, *o*, *p*, *q*, *r*, *s*, the last two fresh).
Bred from larvae collected on Rapa:—

Emergence:	1.v.25.	1 ♂, 1 ♀ (*t*).
,,	2.v.25.	1 ♀ (*u*).
,,	3.v.25.	1 ♀ (*v*).
,,	4.v.25.	1 ♂, 3 ♀ (*w*, *x*, *y*).
,,	5.v.25.	1 ♂, 1 ♀ (*z*).
,,	8.v.25.	2 ♂, 1 ♀ (*a a*).
,,	10.v.25.	1 ♂.
,,	12.v.25.	1 ♂ (larva starved).

Mr. Collenette records that *bolina* was "fairly common in the narrow belt of level and generally marshy ground near sea-level, where its food-plant (*Sida rhombifolia*, L.) was common. On the hilly ground inland, where high winds prevailed, it was only occasionally seen, although the food-plant occurred in sheltered places. The specimens caught were noticeably larger and finer than those from Tahiti and the Marquesas, and were in excellent condition. The sexes were in almost equal proportions, the females being if anything, slightly the more numerous" (*ibid.*, p. 26). The practical equality of the sexes (9 ♀, 8 ♂, recorded by Mr. Collenette on p. 27) bred from the indiscriminately collected Rapa larvae affords strong evidence of the true proportion on this island.

Mr. Collenette considers it possible that the preponderance of males on the other islands, where the specimens were worn, and the apparent equality of the sexes on Rapa, where they were fresh, may be due to the males living a longer life than the females.

These most interesting female forms from Rapa are considered in the following series:—

A. The male-like form *thomsoni* (*moseleyi*), resembling the type but larger. Females—*j*, *n*, *o*.

B. Eight females forming a gradual transition from A to the ♀ var. *montrouzieri*, Butl. (C), with a strong orange border to the wings chiefly developed at F.W. apex, and the principal F.W. mark white. Females, in this order from A to C—*u*, *p*, *t*, *x*, *y*, *a a*, *l*, *v*. Female *v* approaches *montrouzieri* so closely that it might be included under this form.

C. Two *montrouzieri*, but with more blue in H.W. patch and less marginal orange in H.W. Females—*w*, *z*.

D. Three females resembling *montrouzieri*, but with the orange duller in tint and a great development of white in the blue-bordered H.W. patch. These forms would be classed as *naresi*, Butl., but for their greater size and dull orange borders. Females—*s* (transitional to C), *m*, *q*.

E. Two females with the *montrouzieri* pattern, but the addition of "*nerina*-red" to F.W. and a spreading of the orange border over the outer half of the H.W. in *k*, and a less extensive invasion in *r*. The chief mark of H.W. blue. Females—*k*, *r*.

Comparing the chief mark of the hind-wing in the seventeen females, the prominent central white patch forms the main feature in the whole pattern of *m* and *q*, distinct but less conspicuous in *s*. In all others the mark is a blue mirror, with an opaque blue patch on the inner side in most specimens. The central scales of this inner patch are white in a few females.

The Rapa females forcibly recall those from the Cook Islands, as may be inferred when the above descriptions are compared with the account of Mr. H. W. Simmonds' Rarotonga specimens in *Proc. Ent. Soc. Lond.*, 1920, pp. lxxiv, lxxv. Another character in common is the great size of *bolina* in these two localities. These large specimens of *bolina* from Rapa and the much smaller forms collected by the "St. George" Expedition in the Society and Marquesas Islands afford valuable material for an investigation into the possible effects of mechanical selection by wind, as suggested in a note on p. 604 of *Trans. Ent. Soc. Lond.*, 1923 (1924). This is too large a subject to be further considered in the present paper, but data bearing upon it are accumulating to be dealt with, it is hoped, in the near future. It may be mentioned, however, as examples, that the Rapa females *q* and *n* measured 112·0 mm. and 100·0 mm. in expanse, respectively, as compared with 85·0 mm. for female *i* from Nuka Hiva (Marquesas Is.), these being fair samples of the sizes in their respective localities. A series of twenty-one females from Pitcairn Island, kindly lent to me by Mr. C. J. Grist, were similar in size to the Marquesas and strikingly different from the Rapa females. These Pitcairn specimens are all the more interesting because it is almost certain that *bolina* did not exist on the island when it was visited by Commander Walker on 1 June, 1883, although his diary records that "the Malvaceous weed on which the larva . . . feeds was very plentiful." My friend informs me that he showed examples of both sexes to the islanders, who were sure that nothing of the kind had ever been seen there. See also *Ent. Mo. Mag.*, vol. xx, p. 223, where Commander Walker records that "no butterfly is apparently found on the island."

A comparison of the "St. George" and other Pacific material suggests that the *bolina* of the Cook and Southern Islands have sprung at no distant date from a common stock, and the same conclusion may hold for the Marquesas and Society groups, although the *bolina* of the latter have been isolated long enough to become on the average considerably more male-like.

LYCAENIDAE.

Zizera labradus cheesmanae, ssp. nov.

SOCIETY ISLANDS.

Tahiti :—Papeete,	21.ii.25.	1 ♂, 2 ♀.	C.L.C.
	23.ii.25.	10 ♀.	C.L.C.
	12.iii.25.	9 ♂, 1 ♀.	C.L.C.
	iv.25.	1 ♂, 1 ♀.	L.E.C.
Moorea :—	13.iii.25.	2 ♂.	
Raiatea :—	v.25.	11 ♂, 2 ♀.	L.E.C.
	vi.25.	3 ♂.	L.E.C.
Bora Bora :—	10–18.vi.25.	14 ♂.	L.E.C.

The subspecies of *Z. labradus* occurring in the Society Islands is readily distinguishable from other subspecies by its dark and almost unicolorous underside. In both sexes the discal spots on the hind-wing are barely discernible, those on the fore-wing scarcely more conspicuous. The pale crescents separating the marginal from the submarginal series of spots are scarcely discernible, the latter series not inwardly surmounted by the pale cones present in other subspecies. As usual in the species the underside markings are rather less inconspicuous in the female than in the male. On the upperside the female is entirely devoid of marginal markings (except in one specimen out of seven, in which there are very faint marginal lunules in areas 1–3). The blue basal suffusion is slight and does not extend as far as halfway across the wings; it is sometimes absent from the fore-wings.

Types in B.M. from Papeete, Tahiti. The subspecies is named after Miss Cheesman, who accompanied the "St. George" Expedition as far as Tahiti, and remained to collect in the Society Islands after the departure of the "St. George." *Z. labradus* from Samoa and Tonga are referable to this subspecies.

"Fairly common on the waste land and cultivated ground at sea-level, but not met with further inland. Flies closely over grass and miscellaneous plants, frequently settling on flowers."—C. L. C.

Jamides walkeri ruruturi, ssp. nov.

AUSTRAL ISLANDS.

Rurutu, sea-level, 24.iii.25. 1 ♂, 5 ♀. C.L.C.

♂. Does not differ on the upperside from *J. walkeri walkeri* from the Cook Isles. On the underside the ground-colour is pale grey, only very faintly brown-tinted—in *J. walkeri walkeri* it is pale brown, or grey-brown.

♀. The blue areas of the upperside are pale powdery grey-blue—not purplish-blue as in the typical subspecies. The underside is light French grey without any tinge of brown.

The suggestion made by Dr. Seitz, that the lack of a tail in the type specimen of *J. walkeri* is accidental, is groundless. I have very carefully examined the five males in the B.M. None of them ever had tails.

It is curious perhaps that no representative of this group of species, all treated by Dr. Seitz as races of *J. bochus*, has yet turned up in the Society Islands. The above record appears to be the most easterly for the group.

"Taken flying over the purple flowers of the shrub *Vitex trifolia*, L., at the junction of the sea beach with the jungle, and frequently settling on the blossoms."—C. L. C.

Catochrysops taitensis, Boisd.

Lycaena taitensis, Bois., Voy. "Astrolabe," Lep., p. 77, 1832.
Catochrysops lithargyrea pepe, Hopkins, Ins. Samoa, Pt. III, Lep. fasc. 1, p. 55, 1927.

Society Islands.

Raiatea, May 1925. 2 ♂. L.E.C.

Butler (*P.Z.S.*, 1874, pp. 274–291) referred Boisduval's *taitensis* to *Lampides*, and stated that it was in the B.M. He gave as localities Tahiti and Australia. The B.M. collection shows that it was, in fact, to specimens of *L. boeticus*

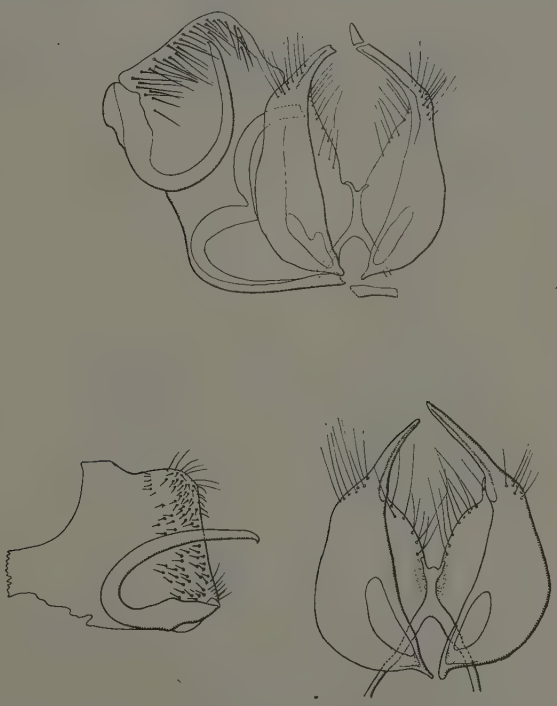


Fig. 1.—Claspers and part of uncus of *Catochrysops taitensis* (upper figure) and *C. lithargyrea* (lower figures).

from Australia that he applied the name; moreover there was neither *L. boeticus* nor *C. taitensis* from Tahiti in the B.M. in 1874 at the time of the publication of his paper. Druce (*E.M.M.*, (2) i, p. 320) followed Butler in synonymising *taitensis* with *boeticus*. These references appear to form the sole basis for assuming the occurrence of *L. boeticus* in Tahiti.

The two males taken by Miss Cheesman, and another in the B.M. taken many years ago in Tahiti by Commander J. J. Walker, agree very well with Boisduval's somewhat brief description. Except for the presence of a moderately well-developed anal spot on the upperside of the hind-wing they agree, too, exactly with the Types of *Catochrysops lithargyrea pepe*, Hopkins. Three

other males, from Fiji, and three males and two females from the New Hebrides, in the B.M., seem also referable to this species, which, in the New Hebrides at least, appears to fly together with *C. lithargyrea*. All 12 ♂ differ from *C. lithargyrea* in being noticeably smaller and in having widely and diffusely but faintly darkened margins on the upperside (the latter character least marked in Samoan specimens), and in having very white, faintly marked undersides. The special characters are well indicated by Hopkins (Ins. Samoa, Pt. III, fasc. 1). A comparison of the androconia (from one specimen of each species only, from New Hebrides) did not produce any distinguishing features. On the other hand, the genitalia of the same two specimens show a few minor differences, tending to confirm the view that *lithargyrea* and *taitensis* are distinct species, that will be best appreciated from the accompanying figures. The claspers in *lithargyrea* are wider in relation to their length than in *taitensis*, and more bulbous in outline (fig. 1); their distal portions narrower and less

Fig. 2.—Extremity of penis of *Catochrysops lithargyrea* (on left) and *C. taitensis* (right).

recurved, preceded by a more pronounced shoulder. The under surface of the lobes of the uncus in *lithargyrea* bear numerous short stout spines which are represented in *taitensis* by more delicate hairs some three or four times longer (fig. 1). The tip of the aedeagus (fig. 2) in *lithargyrea* widens out more than in *taitensis*, and is more sharply truncate; the spines on the extremity of the membranous eversible portion are relatively much longer in *lithargyrea* than in *taitensis* and amongst them is a higher proportion of the short stout spines peculiar to the basal portion of this spiniferous area; above them, in *lithargyrea*, is a small rectangular chitinous plate bearing a number of short broad spines.

Hypojamides, gen. nov.

Of moderately stout build. Fore-wing costa only slightly longer than dorsum; termen rather rounded, a line between apex and tornal angle would be at right angles to dorsum. Hind-wing evenly rounded, tailless. Fore-wing vein 7 ending on costa, almost at apex; vein 6 arising free from cell; vein 5 midway between 4 and 6; vein 2 one and a half times as far from 3 (at origin) as 3 is from 4; veins 11 and 12 free at base, then anastomosing

for about two-fifths of remaining length of vein 12, then strongly divergent. Hind-wing vein 3 just before cell-end; D2 and D3 almost in line, the former about two-thirds length of latter and slightly sinuous. Antennae almost half length of costa, with usual Lycaenine club. Thorax and abdomen moderately stout. Eyes shortly hairy. Palpi with 2nd segment moderately stout, and rather hairy, twice as long as the much more slender and smooth third segment.

Genotype "*Lycaena* (?) *catochloris*," Boisd.

Hypojamides catochloris, Boisd.

Lycaena (?) *catochloris*, Bois., Voy. "Astrolabe," Lep., p. 78, 1832; Butler, P.Z.S., p. 286, 1874.
Nacaduba (?) *catochloris*, Druce, P.Z.S., p. 440, 1892.

♀. *Upperside*, both wings blackish-brown, suffused basally with violet-blue which on the fore-wing reaches two-thirds of the distance to the termen but extends anteriorly only to the anterior edge of the cell, and on hind-wing, between veins 1 and 6, fills the whole area as far as the cell end and then tapers off diffusely, ending about halfway to the margin. On the *underside* there is a pattern formed by short transverse intracellular pale-edged darker lines, which, except for the entire absence of marginal and submarginal markings and of anal ocelli, is almost exactly that of *Jamides bochus*. The colour of the fore-wing is dove-grey, except for a square blotch at the apex which, together with the whole of the hind-wing, is bright, faintly shining green. A dark grey fine anteciliar line to both wings.

Length of fore-wing, 15 mm.

The foregoing descriptions have been drawn up from a solitary female captured by Mr. Collenette on 11.iii.25 in the Fautaua Valley in Tahiti at an elevation of 2500 ft. I have no doubt the specimen is referable to Boisduval's *catochloris*, a species which, since its description in 1832, appears never to have been met with again. Butler referred to it and suggested that it might prove to be a *Danis*; Druce, on the other hand, considered it was probably a *Nacaduba*. Butler's suggestion was nearest to the truth, for the structural characters given above indicate a close alliance with *Thysonotis*, with which indeed *Hypojamides* agrees in the main. It may be separated by the position of the origin of vein 2 of the fore-wing, which is much nearer to vein 3 than in any *Thysonotis*. The appearance of the insect is, of course, very different and is alone sufficient to prevent confusion, the *Jamides*-like pattern, devoid however of anal ocelli and all marginal markings, being most characteristic. It is not referred to in Seitz.

"Taken in the Fautaua Valley, Tahiti, about 11 miles inland. It was flying over *Dracaena* plants on the banks of a stream, among very thick vegetation largely composed of *Hibiscus*, lime, *Dracaena* and *Lantana*. The locality was near the edge of the 'tree fern area,' which commenced 100 ft. higher up the valley. No further specimens were seen during a considerable search."—C. L. C.

Thecla ocrisia, Hew.

Thecla ocrisia, Hew., Desc. Lycaenidae, p. 5, 1868; Draudt, in Seitz, v, p. 775, 1920.

Tahiti:—Itititaa, 1 ♂ bred July 1925. L.E.C.

This common American species, having a range from Mexico to Paraguay and Bolivia, may safely be assumed to have been accidentally introduced. Miss Cheesman was, unfortunately, not able to identify the plant upon which the larva was found.

HESPERIIDAE.

Badamia exclamationis, F.

Papilio exclamationis, Fab., Syst. Ent., p. 530, 1775.
Badamia exclamationis, Seitz, ix, p. 1052, 1927.

MARQUESAS.

Hiva Oa, 4.ii.25. 1 ♀.

This solitary specimen is in rather worn condition. The hyaline spots of the fore-wing are almost as usual in Indian specimens; though perhaps a little broader they are just as long. In its rather pale coloration it approaches *B. atrax*, Butler (= *B. exclamationis subflava*, Waterhouse) from New Caledonia, New Hebrides, Fiji and the Loyalty Isles, a species characterised not only by its general yellow coloration but also by the abbreviated condition of the hyaline spots in areas 2 and 3, and the broadening and shortening of that in the cell. In the New Hebrides and in Fiji *B. exclamationis* and *B. atrax* appear to fly together, a parallel case in some respects to that of *C. lithargyrea* and *C. taitensis* (see above), with the difference that in the case of the Hesperids it is the wide-ranging species (*B. exclamationis*, cf. Hopkins, Ins. Samoa, Pt. III, fasc. 1) that inhabits Samoa, in the Lycaenid the restricted species.

B. exclamationis seems not to have been met with between Samoa and the Marquesas. More material from the Marquesas would probably confirm what this single specimen suggests, namely that it represents a distinct subspecies.

" Taken near Atouana Village, Hiva Oa, at sea-level, flying round a flowering tree, on 4.ii.25. It had been seen previously at the same tree, but was extremely lively and could not be caught. No others were seen after this one specimen was taken. The insect was also seen by Commander Walker on 14 March, 1883, as we may infer from the following words in his presidential address to the Entomological Society in 1920: 'The Hesperidae may also find their eastern limit in Samoa, unless a butterfly that I saw once or twice in Marquesas Islands, but was unable to capture, may belong to the family, as I suspected at the time. . . . In the Marquesas . . . *Danaida* and *Hypolimnas* were the only butterflies that were taken during my visit, though an *Atella?* [*Libythea collenettei*] and the problematical Hesperid previously mentioned, were seen in Nuka-hiva and O-Hiva-oa, two of the larger islands' (*Proc. Ent. Soc. Lond.*, 1919, pp. cvi–cvii (1920))."—C. L. C.

THE ARCTIIDAE, NOCTUIDAE AND SPHINGIDAE OF THE "ST. GEORGE" EXPEDITION, FROM FRENCH OCEANIA

By C. L. Collenette.

[Read October 3rd, 1928.]

Plate XXI and Two Text-figures.

The collection here dealt with comprises the Arctiidae, Noctuidae and Sphingidae taken in the islands of French Oceania during the course of the "St. George" Expedition, 1924–25, to which have been added those obtained by Miss L. E. Cheesman, after leaving the expedition, in the islands of Tahiti, Raiatea and Bora Bora (Society Islands). The collecting from the "St. George" was carried out by Miss C. E. Longfield and the author, with occasional assistance from other members of the expedition.

Material was obtained from :—

The Marquesas Islands—Hiva Oa, Tahuata, Fatu Hiva and Nuka Hiva.

The Tuamotu Archipelago—Napuka and Fakarava.

The Society Islands—Tahiti, Moorea, Raiatea and Bora Bora.

Rurutu in the Austral Islands, and

Rapa Island.

For descriptions of these islands see :—

"A Contribution towards the Insect Fauna of French Oceania," by Miss L. E. Cheesman, F.E.S., *Trans. Ent. Soc. Lond.*, 1927, Part I.

"On Micro-lepidoptera from the Galapagos Islands and Rapa," by Edward Meyrick, B.A., F.R.S., *Trans. Ent. Soc. Lond.*, 1926, Part II.

The most interesting species were taken at light in the elevated regions of the volcanic islands, especially on Mt. Temetio in Hiva Oa at a height of 3500 ft. There is little doubt that further collecting on these mountains would yield extremely interesting results.

The terminology adopted for the wing-neuration is the Comstock-Needham system. The colour values for the moths are from Ridgway's "Color Standards and Color Nomenclature," and the colours of the larvae from descriptions taken in the field.

The material dealt with is in the collection of the British Museum. Records of specimens in the Museum collection, taken in the above-mentioned islands by previous collectors, have also been included in the paper. Among these is a previously undescribed species of *Hypena* taken by Commander J. J. Walker in Tahiti in 1883.

I am greatly indebted to Mr. W. H. T. Tams, F.E.S., for assistance rendered during the writing of the paper.

ARCTIIDAE.

Nolinae.

1. Celama insularum, sp. n.

(Plate XXI, fig. 2.)

♂. Body, palpus and antenna buffy brown, palpus porrect, the 2nd segment roughly scaled above and below, the 3rd moderate, slightly scaled and somewhat downturned.

Fore-wing tawny olive; a fuscous antemedial fascia, outwardly oblique and well defined from costal nervure to middle of cell, then inwardly and again outwardly oblique to vein *Cu*2, then inwardly oblique to 2nd anal vein and outwardly oblique to inner margin; a series of faint postmedial fuscous spots on the veins; terminal line cream buff; fringe tawny olive, irrorated with fuscous and with a medial line of cream buff. Hind-wing cartridge buff; a faint discocellular striga of tawny olive; terminal line cream buff, defined proximally with tawny olive shading, especially towards apex; fringe tawny olive. Underside cartridge buff, the preterminal area of both wings, the fore-wing above median nervure and the hind-wing above subcostal nervure, heavily irrorated with tawny olive; terminal line cream buff, fringe tawny olive.

♀. Similar.

Expanse: 15 mm.

Rapa Island.

1 ♂ (holotype) and 1 ♀ (allotype) at light, 800 ft., 15 and 17.iv.25.

Society Islands.

Tahiti. 1 ♂ at light, 300 ft., Papeete, 4.iii.25; 1 ♀ at light, sea-level, Papeete, 24.ii.25.

Arctiinae.

2. **Utetheisa pulchelloides,** Hmpsn.

Utetheisa pulchelloides, Hmpsn., A.M.N.H. (7), xix, p. 239 (1907).

Tuamotus.

Napuka. 13 ♂♂, 6 ♀♀ flying by day, 8.ii.25; 6 ♂♂, 9 ♀♀ bred from larvae, Feb.–March 1925.

Fakarava. 1 ♂ flying by day, 12.ii.25.

Larva. (Napuka.) Body white, with black markings. A broad white median stripe bordered with heavy black spots and markings. Laterally a broad stripe of white containing sparse black spots and oblique stripes, bordered below by an area in which the black markings predominate. Ventral surface greyish-white. Body sparsely covered with greyish-white setae arising from black tubercles. Legs black and white; prolegs yellowish, tipped with orange. Head deep orange, with white inverted **V**. Pupated in captivity in very slight silken cocoon, generally on withered leaf. Pupal stage in 15 specimens from 9 to 19 days. Food-plant, *Tournefortia argentea,* L.

A single ♂ specimen of *U. ornatrix,* Linn., in the British Museum collection, bears a museum label "Marquesas," and is so recorded in Hampson's Catalogue, Vol. iii, p. 486. Reference to the collector's original locality number, which is still on the pin, and to a copy of his field notes, shows that the insect was undoubtedly taken at Callao in Peru.

NOCTUIDAE.

Agrotinae.

3. **Chloridea assulta,** Guén.

Heliothis assulta, Guén., Noct., ii, p. 178 (1852).

Society Islands.

Tahiti. 1 ♂ beaten from herbage, 28.ii.25.

Also 1 ♂ in the British Museum collection from Tahiti (*J. J. Walker*).

HADENINAE.

4. **Tiracola plagiata,** Walk.

Agrotis plagiata, Walk., List. Lep. Ins. B.M., xi, p. 740 (1857).

MARQUESAS.

Hiva Oa. 3 ♀♀ at light, 600 ft., 26 & 29.xii.24; 2 ♀♀ at light, near sea-level, 1.i.25; 2 ♀♀ at light, 1200 ft., 3.i.25; 1 ♀ at light on ship in harbour, 26.i.25.

Nuka Hiva. 1 ♀ at light, 300 ft., 22.i.25.

Also 1 ♀ in the British Museum collection from Tahiti (*J. J. Walker*), and 1 ♂ from Nuka Hiva, Marquesas (*J. J. Walker*).

ACRONYCTINAE.

5. **Callopistria meridionalis,** sp. n.

(Plate XXI, fig. 4.)

♀. Palpus vandyke brown, irrorated with white. Antenna with the shaft vandyke brown basally, gradually becoming lighter in colour distally. Head with frons and vertex vandyke brown, irrorated with white. Thorax vandyke brown mixed with russet. Abdomen dorsally drab, each segment edged distally with light buff, and with dorsal crests vandyke brown; ventrally light buff at base, then drab, with an ochraceous tawny terminal tuft. Pectus light buff. Legs vandyke brown irrorated lightly with white, with light buff on inner side; mid tibia with some long light buff and fuscous hair scales, hind tibia with some long light buff hair scales. Fore-wing warm sepia; a tuft of richly coloured warm sepia scales at wing-base on inner margin; a subbasal fascia, white faintly tinged with rose pink, bowed (concavity basad); an antemedial fascia white basad, sepia medially, rose pink terminad, roughly oblique outwardly from costa at one-third to base of vein *Cu*2, thence oblique inwardly to inner margin at one-third, with before it a richly coloured warm sepia area between the cell and the anal vein; beyond the antemedial line in the cell is a round warm sepia velvety spot, with a white edge in the form of a U, the distal arm of which appears to be prolonged round the upper end of the reniform stigma and down its distal edge; the reniform stigma is composed of an inwardly oblique pink streak edged with sepia; postmedial fascia commencing as a sharp inwardly oblique white dash on costa, angling sharply apicad parallel with costa, here becoming a narrow rose-pink fascia with two parallel sepia lines running through it, and turning to run at right angles to the median veins, thence strongly inwardly oblique to a point above anal vein, where it is sharply angled and outwardly oblique to inner margin; four small light buff spots on costa before apex, and a longer one at apex; a white subterminal fascia consisting of three inwardly oblique dashes to vein *M*1, thence making a sharp dip towards the postmedial, turning sharply back and out to termen in a broad distinct dash, and continuing to tornus almost parallel with postmedial fascia; fringe fuscous, lighter tipped, with a light line at its base. Hind-wing light buff wholly suffused with fuscous, darkening slightly towards termen, and with a faint discocellular striga and postmedial fascia; fringe as in fore-wing. Underside of fore-wing pale buff, suffused with fuscous except for a slightly bowed postmedial fascia (concavity basad) and a subterminal area from vein *M*2 to tornus; hind-wing similar, less heavily infuscate but with a prominent discocellular mark and a broad post-medial fascia, the latter composed of an inner dark fascia separated from a somewhat less heavily infuscate but broader fascia by a fine pale buff line, roughly crenulate.

♂. Not so sombrely coloured as the ♀, and with more contrasts. Antenna with basal

quarter, except scape, warm sepia. Fore-wing with ground-colour varying from vandyke brown to warm sepia, and with markings more prominent than in the ♀. Hind-wing rather lighter than in the ♀ on both upper- and undersides.

Expanse: ♂♂ 32–33 mm., ♀♀ 28–30 mm.

Austral Islands.

Rurutu. 1 ♀, beaten from herbage, 23.iii.25.

Rapa Island.

1 ♂ (allotype) at light, 800 ft., 17.iv.25; 1 ♀ (holotype) at light, near sea-level, 11.iv.25; also 1 ♂, 11 ♀♀ at light, near sea-level, 11–14.iv.25; 1 ♂, 1 ♀ at light, 800 ft., 15.iv.25.

Mr. Tams has investigated the genitalia of this insect and of *C. maillardi*, Guén., and is of opinion that separate specific or sub-specific rank is indicated. The two may be readily separated by the shape of the postmedial fascia in the fore-wing.

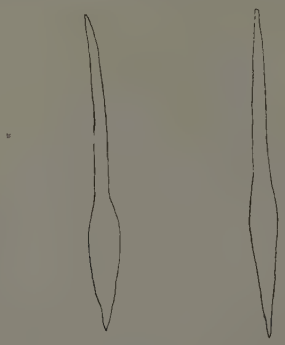


Fig. 1.—Scales from dorsal surface of tegumen of male genital armature.
Left: *C. maillardi*. Right: *C. meridionalis*.

6. **Callopistria ouria**, sp. n.

(Plate XXI, fig. 3.)

♂. Palpus, antennal shaft, head and thorax auburn; pectus light buff, somewhat infuscate laterally; tarsi warm buff with paler rings, the mid tibia and first joint of tarsus fringed with long hair; antenna with the basal third of shaft slightly thickened, down-curved at middle, minutely serrate at end of thickened portion; abdomen fuscous mixed with buff pink to pinkish vinaceous, and with paler segmental rings, the dorsal crests auburn. Fore-wing vinaceous russet suffused with deep vinaceous; inner margin whitish at base; two light buff sub-basal streaks from below costa to middle of cell; a prominent vandyke brown claviform spot not reaching the antemedial, divided at two-thirds by a warm buff fascia; antemedial fascia warm buff slightly defined by auburn on inner side, sharply oblique outwards to cell, then incurved to median nervure (concavity tornad), then inwardly oblique to inner margin; medial area from antemedial to postmedial, and extending upwards to subcostal nervure, suffused with velvety vandyke brown; orbicular and reniform vinaceous brown defined by warm buff, the orbicular oblique V-shaped, the reniform oblique, their lower extremities confluent; postmedial fascia of ground-colour, defined proximally by vandyke brown, with a fine fuscous line proximally, and edged distally with warm buff, commencing above inner edge of reniform, inwardly oblique to near reniform, sharply angled and running parallel with costa for a short distance, then

curving round end of cell to vein *Cu*2, slightly recurving to inner margin; several light points beyond it on costa; subterminal fascia light to warm buff, inwardly oblique to above vein *M*2, then angled and outwardly oblique to vein *M*3 and almost to termen, where it is again apparently angled, the apex of the angle obsolescent, thence oblique (slightly bowed) to inner margin; a broad band of velvety vandyke brown from costa to inner margin and extending from postmedial fascia to subterminal fascia; terminal area vinaceous brown shaded with vandyke brown, and with a series of velvety vandyke brown spots before the termen, faintly edged proximally with light buff. Hind-wing light buff, distal half infuscate, and with a fuscous discoidal bar and a narrow and sinuous postmedial fascia; fringe warm buff to pinkish vinaceous, with fuscous basal line. Underside of both wings light buff, suffused with fuscous, costally pinkish vinaceous; fore-wing with a sinuous medial shade, pronounced at end of cell, and a light buff subterminal fascia similar to that on upperside; hind-wing with a pronounced fuscous black discoidal bar, an irregular sinuous fuscous postmedial fascia, and a faint fuscous subterminal shade; fringes as on upperside.

♀. Similar.

Expanse: ♂ 38 mm., ♀♀ 40–41 mm.

MARQUESAS.

Hiva Oa. At light, 3500 ft., Mt. Temetio, 1 ♂ (holotype), 1 ♀ (allotype), also 4 ♂♂ and 11 ♀♀, 28.i.25.

Fatu Hiva. At light, 2000 ft., 3 ♂♂, 31.i.25.

7. **Prodenia litura**, Fabr.

Noctua litura, Fabr., Syst. Ent., p. 601 (1775).

MARQUESAS.

Hiva Oa. 1 ♂ at light on ship in harbour, 29.i.25; 2 ♀♀ at light, 300 ft., 30.xii.24 and 2.i.25; 1 ♂, 2 ♀♀ bred from larvae, Jan.–Feb. 1925.

Fatu Hiva. 1 ♀ at light, 2000 ft., 31.i.25; 2 ♀♀ bred from larvae, Jan.–Feb. 1925.

Tahuata. 1 ♀ at light, 500 ft., 10.i.25.

Nuka Hiva. 2 ♂♂, 7 ♀♀ at light, 300 ft., 22–24.i.25; 1 ♀ bred from larva, Jan.–Feb. 1925.

SOCIETY ISLANDS.

Tahiti. 2 ♂♂ at light, near sea-level, Papeete, 24.ii. and 18.iii.25; 1 ♀ at light, 1500 ft., Fautaua Valley, 16.iii.25. 1 ♂ bred from larva, emerged 10.ix.25 (*L. E. Cheesman*).

Raiatea. 1 ♀, sea-level, N.E. of island, 17.v.25 (*L. E. C.*).

AUSTRAL ISLANDS.

Rurutu. 2 ♀♀ at light, 650 ft., 23.iii.25.

RAPA ISLAND.

2 ♂♂, 3 ♀♀ at light, near sea-level, 12 and 14.iv.25; 2 ♂♂, 2 ♀♀ at light, 800 ft., 15.iv.25; 2 ♂♂, 1 ♀ bred from larvae, April–May 1925.

Also in the B.M. collection from Fatu Hiva and Nuka Hiva (*J. J. Walker*), Tahiti (*G. F. Mathew*), and Moorea (*J. J. W.*).

Larva. Six taken on Rapa Island varied considerably in coloration, the general ground-colour of different larvae ranging from grey to brown and dark brownish-black. The ground-colour is described by Moore, in *Lep. Ceyl.*, iii, p. 19, as pale violet brown. Food-plants (Hiva Oa), *Piper* sp. and Taro, *Colocasia antiquorum*, Schott, at 1200 and 3000 ft. respectively; (Fatu Hiva), a plant resembling watercress, growing in damp ground; (Nuka Hiva), Guava, *Psidium Guajava*, Linn.; (Tahiti), Guava, (*L. E. C.*); (Rapa), *Verbena officinalis*, Linn. and *Erigeron bonariensis*, Linn. Pupal stage, Hiva Oa, Jan., 8–12 days; Fatu Hiva, Feb., 9 days; Nuka Hiva, Feb., 12 days; Rapa, May, 14–15 days.

8. **Spodoptera mauritia,** Boisd.

Hadena mauritia, Boisd., Fauna Ent. Madag., p. 92 (1833).

MARQUESAS.

Nuka Hiva. 1 ♂, 2 ♀♀ at light, 300 ft., 24.i.25.

SOCIETY ISLANDS.

Tahiti. 1 ♂ resting by day on room wall of ruined bungalow, 300 ft., Papeete, 20.ii.25; 1 ♀, 26.iv.25 (*L. E. Cheesman*).

Raiatea. 12 ♂♂, 17 ♀♀, sea-level, N.E. of island, 14–17.v.25 (*L. E. C.*).

RAPA ISLAND.

2 ♀♀ at light, 11.iv.25.

Also specimens in the B.M. collection from Nuka Hiva (*J. J. Walker*); Marquesas (*G. F. Mathew*); Tahiti, Moorea and Mehetia (*C. S. Betton*).

9. **Perigea serva,** Walk.

Celaena serva, Walk., List Lep. Ins. B.M., xv, p. 1689 (1858).

MARQUESAS.

Hiva Oa. 1 ♀ bred from larva, January 1925.

SOCIETY ISLANDS.

Tahiti. 1 ♀ beaten from herbage, Papeete, 28.ii.25.

Raiatea. 1 ♂, sea-level, N.E. of island, 17.v.25 (*L. E. Cheesman*).

Larva. (Hiva Oa.) Food-plant, *Piper* sp., at 1200 ft. Pupal stage, 12 days.

10. **Elydna nonagrica,** Walk.

Curgia nonagrica, Walk., Journ. Linn. Soc. Zool., vii, p. 166 (1864).

SOCIETY ISLANDS.

Tahiti. 1 ♀ at light, 300 ft., Papeete, 24.ii.25; 1 ♀ at light on ship in Papeete harbour, 25.ii.25; 2 ♀♀ at light, 2500 ft., Fautaua Valley, 13.iii.25.

RAPA ISLAND.

2 ♂♂, 3 ♀♀ at light, near sea-level, 11–14.iv.25; 1 ♂, 1 ♀ at light, 800 ft., 15.iv.25.

11. **Chasmina tibialis,** Fabr.

Bombyx tibialis, Fabr., Syst. Ent., p. 578 (1775).

MARQUESAS.

Hiva Oa. 1 ♂, 2 ♀♀ at light, 600 ft., 26 and 28.xii.24; 1 ♀ at light, near sea-level, 1.i.25; 1 ♂ at light, 1200 ft., 3.i.25.

Nuka Hiva. 1 ♀ at light, 300 ft., 22.i.25.

SOCIETY ISLANDS.

Tahiti. 1 ♂ at light on ship in Papeete harbour, 17.ii.25.

Raiatea. 3 ♀♀, sea-level, 16–17.v.25 (*L. E. Cheesman*).

RAPA ISLAND.

1 ♂, 3 ♀♀ at light, near sea level, 11–12.iv.25.

Also in the B.M. collection from Tahiti, 3 ♂♂, 6 ♀♀ (*J. J. Walker*) and 2 ♀♀ (*G. F. Mathew*).

ERASTRIINAE.

12. **Eublemma rivula,** Moore.

Thalpochares rivula, Moore, Lep. Atk., p. 140 (1882).

SOCIETY ISLANDS.

Tahiti. 2 ♂♂ beaten from herbage, sea-level, Papeete, April, 1925 (*L. E. Cheesman*); 1 ♂ near Papeete, March–April 1925 (*L. E. C.*).

Raiatea. 1 ♂, sea-level, N.E. of island, 20.v.25 (*L. E. C.*); 1 ♂, sea-level, S.E. of island, 3.vi.25 (*L. E. C.*).

Bora Bora. 1 ♂ in vanilla plantation, N. of island, 20.vi.25 (*L. E. C.*); 1 ♀, sea-level, N. of island (*L. E. C.*).

13. **Amyna natalis,** Walk.

Berresa natalis, Walk., List Lep. Ins. B.M., xvi, p. 214 (1858).

RAPA ISLAND.

1 ♂, 1 ♀ beaten from herbage, 12.iv.25.

14. **Amyna octo,** Guén.

Perigea octo, Guén., Noct., i, p. 233 (1852).

MARQUESAS.

Fatu Hiva. 1 ♀ beaten from herbage, 5.i.25.

Tahuata. 1 ♂ beaten from herbage, 11.i.25.

Nuka Hiva. 1 ♂, 3 ♀♀ at light, near sea-level, 15–23.i.25; 4 ♂♂, 8 ♀♀ at light, 300 ft., 22 and 24.i.25.

SOCIETY ISLANDS.

Tahiti. 1 ♂ beaten from herbage, Fautaua Valley, March 1925 (*L. E. Cheesman*); 1 ♂, 1 ♀, 500 ft., Papeete, 30.iii.25 (*L. E. C.*). 1 ♂, 2 ♀♀ beaten from herbage, Papeete, 20.ii.–5.iii.25; 1 ♀ at light on ship in Papeete Harbour, 22.ii.25.

Bora Bora. 1 ♀, sea-level, N.W. of island, 10.vi.25 (*L. E. C.*).

Hampson's Ab. 1 (ab. *axis,* Guén.), with the lower part of reniform filled in with white, is present in the series from Nuka Hiva and Tahiti.

Also in the B.M. collection from the Marquesas (*J. J. Walker* and *G. F. Mathew*), and Tahiti (*J. J. W.*).

15. **Eustrotia ritsemae,** Snell.

Erastria ritsemae, Snell., Tijd. v. Ent., xxiii, p. 57 (1880).

SOCIETY ISLANDS.

Tahiti. 1 ♂, Fautaua Valley, March 1925 (*L. E. Cheesman*). 3 ♂♂, 10 ♀♀ beaten from herbage, 20.ii.25.

Raiatea. 1 ♀, 1500 ft., N. of island, 1.vi.25 (*L. E. C.*); 1 ♂, sea-level, S.E. of island, 3.vi.25 (*L. E. C.*).

AUSTRAL ISLANDS.

Rurutu. 2 ♂♂, 1 ♀ beaten from herbage, 23.iii.25.

Also in the B.M. collection from Tahiti (*J. J. Walker, G. F. Mathew, M. J. Nicoll*).

EUTELIINAE.

16. **Phlegetonia delatrix,** Guén.

Penicillaria delatrix, Guén., Noct., ii, p. 304 (1852).

SOCIETY ISLANDS.

Raiatea. 1 ♀ at light, sea-level, N.W. of island, 27.v.25 (*L. E. Cheesman*).

RAPA ISLAND.

1 ♂ at light, 800 ft., 15.iv.25.

STICTOPTERINAE.

17. **Gyrtona divitalis,** Walk.

Gyrtona divitalis, Walk., List Lep. Ins. B.M., xxvii, p. 91 (1863).

SOCIETY ISLANDS.

Raiatea. 2 ♀♀, sea-level, N.E. of island, 20 and 21.v.25. (*L. E. Cheesman*).

WESTERMANNIINAE.

18. **Earias huegeli,** Rogenh.

Earias huegeli, Rogenh., Verh. zool.-bot. Ges. Wien, xx, p. 872 (1870).

SOCIETY ISLANDS.

Tahiti. 2 ♂♂, 2 ♀♀ beaten from herbage, Papeete, 20 and 28.ii.25.

Raiatea. 1 ♂, 1500 ft., N. of island, 1.vi.25 (*L. E. Cheesman*).

Bora Bora. 1 ♀, sea-level, W. of island, 11.vi.25 (*L. E. C.*); 2 ♂♂, 500 ft., in fern, N. of island, 16.vi.25 (*L. E. C.*); 1 ♀, 300 ft., valley below Popoti, 16.vi.25 (*L. E. C.*); 1 ♀, on coral point at sea-level, S. of island, 17.vi.25 (*L. E. C.*).

AUSTRAL ISLANDS.

Rurutu. 1 ♀ at light, 400 ft., 24.iii.25.

Also 1 ♀ in the B.M. collection from Tauteia, Tahiti (*M. J. Nicoll*); and 1 ♀ from Fatu Hiva, Marquesas (*J. J. Walker*).

CATOCALINAE.

19. **Anua coronata,** Fabr.

Noctua coronata, Fabr., Syst. Ent., p. 596 (1775).

SOCIETY ISLANDS.

Tahiti. 1 ♀ at light, Papeete, 18.iii.25.

20. **Achaea marquesanus,** sp. n.

(Plate XXI, fig. 1.)

♂. Palpus, antennal shaft, head and thorax cinnamon brown; the 3rd segment of palpus rather short; antenna with very short cilia and bristles; pectus and legs snuff brown; tarsi ringed with white, first segment of hind tarsus not fringed with hair, base and tip of spurs white; abdomen snuff brown. Fore-wing cinnamon brown; antemedial fascia fuscous, incurved to cell (convexity basad), then waved and incurved to inner margin; orbicular small, pale olive buff defined faintly by sepia; two sepia medial fasciae from vein

*R*2 to inner margin, indistinct and slightly waved; postmedial fascia sepia, edged distally from costa to vein *R*5 with light buff, and thereafter faintly marked with light buff at the point of junction with each vein, outwardly oblique from costa to vein *M*1, then parallel with termen and crenate (concavities basad); several light points beyond it on costa; a broad area of sayal brown, slightly iridescent, extending distally from postmedial fascia, the outer edge roughly parallel with termen; a series of preterminal fuscous black points placed interneurally; preterminal area densely irrorated with warm buff, its proximal edge incurved from apex to tornus; a faint cinnamon brown terminal line; fringe warm buff, with two lines of sudan brown running through it. Hind-wing fuscous, with faint medial and postmedial fasciae of warm buff; a series of preterminal black points placed interneurally; preterminal area, terminal line and fringe as in fore-wing. Underside of both wings warm buff, fore-wing suffused, hind-wing densely irrorated with cinnamon brown; preterminal black points and terminal line as on upperside; fringe cartridge buff, with two lines of sudan brown running through it; hind-wing with a cinnamon brown crenate medial fascia (concavities basad).

Expanse: 62 mm.

Nearest in appearance to *Achaea sordida*, Walk. (1865), but lacks the remarkable dilate mid tibia.

MARQUESAS.

Hiva Oa. 1 ♂ (holotype) at light, Mt. Temetio, 3500 ft., 28.i.25.

21. **Achaea janata**, Linn.

Geometra janata, Linn., Syst. Nat., Ed. X, p. 527 (1758).

MARQUESAS.

Hiva Oa. 2 ♂♂, 1 ♀ at light, 600 ft., 26 and 29.xii.24.

Nuka Hiva. 3 ♂♂ at light, near sea-level, 21.i.25.

SOCIETY ISLANDS.

Tahiti. 1 ♂ flying in sun, Fautaua Valley, 1500 ft., 3.iii.25; 1 ♀ at light, Papeete, 18.iii.25.

RAPA ISLAND.

8 ♂♂, 2 ♀♀ flying by day round trees of *Hibiscus tiliaceus*, Linn., 11–17.iv.25; 1 ♂, 4 ♀♀ at light, near sea-level, 11–12.iv.25; 1 ♂, 2 ♀♀ at light, 800 ft., 15 and 17.iv.25; 5 ♂♂, 9 ♀♀ bred from larvae, April–May 1925.

Also in the B.M. collection from Nuka Hiva (*J. J. Walker*), and Tahiti (*J. J. W.* and *G. F. Mathew*).

Larva. Food-plant (Rapa), Castor oil plant, *Ricinus communis*, Linn.

22. **Grammodes oculicola**, Walk.

Grammodes oculicola, Walk., List Lep. Ins. B.M., xiv, p. 1446 (1858).

AUSTRAL ISLANDS.

Rurutu. 1 ♂ at light, 650 ft., 23.iii.25.

23. **Hypaetra discolor**, Fabr.

Noctua discolor, Fabr., Ent. Syst., iii, (2), p. 50 (1794).

MARQUESAS.

Hiva Oa. 1 ♂ at light on ship in harbour, 31.xii.24; 3 ♂♂ at light, near sea-level, 27 and 30.xii.24; 2 ♂♂, 1 ♀ at light, 600 ft., 26.xii.24; 1 ♀ at light, 3500 ft., 28.i.25.

Fatu Hiva. 1 ♂ at light, 600 ft., 7.i.25.
Tahuata. 2 ♂♂ at light, 500 ft., 10.i.25; 1 ♂ at light, 850 ft., 12.i.25.
Nuka Hiva. 1 ♂ at light, 300 ft., 24.i.25.

Also in the B.M. collection from Nuka Hiva, Tahiti and Moorea (*J. J. Walker*).

24. **Mocis frugalis,** Fabr.

Noctua frugalis, Fabr., Syst. Ent., p. 601 (1775).

MARQUESAS.
Hiva Oa. 2 ♂♂ beaten from herbage, near sea-level, 27.xii.24; 1 ♂ beaten from herbage, Mt. Temetio, 3000–3500 ft., 27.i.25.
Tahuata. 1 ♂ beaten from herbage, 200 ft., 14.i.25.
Fatu Hiva. 4 ♂♂, 1 ♀ beaten from herbage, near sea-level to 2000 ft., 5–6.i.25; 1 ♂ bred from larva, Jan.–Feb. 1925.
Nuka Hiva. 1 ♂, 1 ♀ beaten from herbage, 500–1000 ft., 16.i.25; 1 ♀ bred from larva, Jan.–Feb. 1925.

TUAMOTUS.
Napuka. 1 ♂, 2 ♀♀ beaten from vegetation, 8.ii.25.

SOCIETY ISLANDS.
Tahiti. 1 ♀ beaten from herbage, near sea-level, Papeete, 20.ii.25; 1 ♀, 1500 ft., Papeete, March 1925 (*L. E. Cheesman*); 1 ♀, 1500 ft., Lake Vaihiria, 19.vii.25 (*L. E. C.*); 1 ♂, 2000 ft., 7.v.25 (*L. E. C.*); 1 ♂ at light, 1500 ft., Fautaua Valley, 16.iii.25; 1 ♂ at light, near sea-level, Hitiaa, 9.vii.25 (*L. E. C.*).
Raiatea. 2 ♂♂, 1500 ft., N. of island, 29.v.–1.vi.25 (*L. E. C.*); 1 ♀ at sea-level, S.E. of island, 3.vi.25 (*L. E. C.*).
Bora Bora. 1 ♀ at sea-level, N. of island, 15.vi.25 (*L. E. C.*).

AUSTRAL ISLANDS.
Rurutu. 1 ♂ at light, 650 ft., 23.iii.25.

RAPA ISLAND.
1 ♂ flying among herbage, 800 ft., 13.iv.25; 1 ♂ at light, near sea-level, 14.iv.25; 1 ♂ at light, 800 ft., 15.iv.25; 2 ♀♀ flying among herbage, 11 and 15.iv.25.

Also in the B.M. collection from Hiva Oa and Fatu Hiva (*J. J. Walker*), Tahiti (*G. F. Mathew*), and Rapa (*J. J. W.*).

Larva. (Nuka Hiva.) Feeding on a species of grass in exposed situation at 2500 ft., pupal stage 10 days. (Fatu Hiva), also feeding on a grass, pupal stage 11 days.

25. **Mocis trifasciata,** Steph.

Catephia trifasciata, Steph., Ill. Brit. Ent. Haust., iii, p. 128 (1829).

MARQUESAS.
Hiva Oa. 3 ♂♂ at light, 600 ft., 26–29.xii.24; 1 ♂ at light, near sea-level, 30.xii.24; 1 ♀ beaten from herbage, 29.xii.24.
Fatu Hiva. 2 ♀♀ at light, 600 ft., 7.i.25; 1 ♂, 1 ♀ beaten from herbage, 6.i.25.
Tahuata. 1 ♀ beaten from herbage, 13.i.25.
Nuka Hiva. 7 ♂♂ at light, 300 ft., 22 and 23.i.25; 1 ♂, 3 ♀ beaten from herbage, 500–1000 ft., 16.i.25.

Society Islands.

Raiatea. 1 ♂, 1 ♀, sea-level, N.E. of island, 16 and 29.v.25 (*L. E. Cheesman*).

Bora Bora. 1 ♂, sea-level, N. of island, 15.vi.25 (*L. E. C.*); 2 ♀♀, sea-level, N.W. of island, 10 and 11.vi.25 (*L. E. C.*).

Austral Islands.

Rurutu. 2 ♂♂ at light, 400 ft., 24.iii.25; 4 ♀♀ beaten from herbage, 23.iii.25.

Also in the B.M. collection from Hiva Oa and Tahiti (*J. J. Walker*).

Phytometrinae.

26. **Phytometra chalcites,** Esp.

Noctua chalcites, Esp., Nat. eur. Schmett, iv, pl. 141, fig. 3 (1789), p. 447 (1798).

Marquesas.

Hiva Oa. 3 ♂♂ at light, 30.xii.24.

Nuka Hiva. 1 ♂ at light, 23.i.25.

Society Islands.

Tahiti. 1 ♂, Hitiaa, 9.vii.25 (*L. E. Cheesman*); 2 ♂♂ beaten from herbage, Papeete, 20.ii and 5.iii.25.

Raiatea. 1 ♀, sea-level, N.E. of island, 22.v.25 (*L. E. C.*).

Austral Islands.

Rurutu. 1 ♀ at light, 650 ft., 23.iii.25.

Rapa Island.

1 ♂, 1 ♀ (i.c.), beaten from herbage, 11.iv.25; 1 ♂ flying by day among herbage and one ♀ beaten from herbage, 12.iv.25; 1 ♀, 1 ♂ at light, 800 ft., 15 and 17.iv.25.

Also in the B.M. collection from the Marquesas (*J. J. Walker*), Tahiti (*J. J. W.*), Moorea (*J. J. W.* and *G. F. Mathew*), and Rapa (*J. J. W.*).

27. **Phytometra albostriata,** Brem.

Plusia albostriata, Brem. & Grey, Beitr. Schmett. N. China, p. 18 (1853).

Rapa Island.

3 ♂♂, 4 ♀♀ bred from larvae, April–May 1925.

Larva. Bright grass green, segmental divisions somewhat lighter. Skin rather transparent. Dorsally, three pairs of irregular white stripes, longitudinally for whole length of body. Laterally, a broader white stripe for whole length of body, continued on anal prolegs. Minute white spots and sparse minute black setae over whole of body. Legs yellow green, prolegs bright grass green with whitish tips. Prolegs not present on 3rd and 4th abdominal segments. Head yellow green, mouth-parts brown. Length, $1\frac{3}{16}$th in. Food-plant, *Erigeron bonariensis*, Linn. The larva frequently rests on anal prolegs with body straightened and held at an angle of some 45° to the stem of the plant.

Pupa. Shiny, dark brown dorsally, shading off to brownish-green on underside of abdomen. Wing-cases, etc., light brown. Proboscis covering ending as a blunt point, free of body, tipped with dark brown. Cremaster large. Length, $\frac{11}{16}$th in. Cocoon white and semi-transparent.

OPHIDERINAE.

28. **Polydesma umbricola,** Boisd.

Polydesma umbricola, Boisd., Fauna Ent. Madag. Lep., p. 108 (1833).

SOCIETY ISLANDS.

Tahiti. 1 ♂, 1 ♀ (i.c.) 2000 ft., 6.v.25 (*L. E. Cheesman*). 3 ♀♀ at light, near sea-level, Papeete, 27.ii. and 18.iii.25; 1 ♂, 1 ♀ beaten from herbage, Papeete, 22.ii.25; 3 ♂♂, 4 ♀♀ resting by day on room walls of ruined bungalow, 300 ft., Papeete, 20.ii.25; 4 ♂♂, 1 ♀ bred from larvae, Feb.-March 1925.

Raiatea. 1 ♂, sea-level, N.E. of island, 16.v.25 (*L. E. C.*).

Also 1 ♂ in the B.M. collection from Moorea (*C. S. Betton*).

Larva. (Tahiti.) Found in numbers by day under stones, etc., at the foot of a large acacia-like tree, the leaves of which they accepted in captivity. Pupal stage, 14–16 days.

29. **Aedia sericea,** Butl.

Anophia sericea, Butl., A.M.N.H., (5) x, p. 230 (1882).

AUSTRAL ISLANDS.

Rurutu. 1 ♂ at light, 400 ft., 24.iii.25.

30. **Anomis flava flava,** Fabr.

Noctua flava, Fabr., Syst. Ent., p. 601 (1775).

MARQUESAS.

Hiva Oa. 1 ♂ beaten from herbage, Mt. Temetio, 2500 ft., 31.xii.24.

SOCIETY ISLANDS.

Tahiti. 1 ♀, Hitiaa, 11.vii.25 (*L. E. Cheesman*). 1 ♀ beaten from herbage, Papeete, 12.iii.25.

RAPA ISLAND.

1 ♂ at light, near sea-level, 12.iv.25; 1 ♂ at light, 800 ft., 15.iv.25.

Also 1 ♂ in the B.M. collection from Nuka Hiva (*J. J. Walker*).

31. **Anomis vitiensis,** Butl.

Gonitis vitiensis, Butl., Trans. Ent. Soc. Lond., p. 408 (1886).

SOCIETY ISLANDS.

Tahiti. 2 ♀♀ bred from larvae, July, 1925 (*L. E. Cheesman*).

Raiatea. 1 ♀, sea-level, N.E. of island, 22.v.25 (*L. E. C.*); 1 ♂ at light, sea-level, N.E. of island, 8.vi.25 (*L. E. C.*).

AUSTRAL ISLANDS.

Rurutu. 3 ♀♀ beaten from herbage, 23.iii.25.

RAPA ISLAND.

1 ♀ at light, 12.iv.25; 3 ♂♂ bred from larvae, April-May 1925.

Larva. (Rapa.) Deep grass green, ventrally bluish-green. Skin rather transparent. Tubercles white with black centres, each bearing a short black seta. Spiracles olive green edged with black, each surrounded by a brownish area. Legs and prolegs deep grass green, the latter, except on 3rd abdominal segment, tipped with brown. Head yellow green, mouth-parts orange brown. Length 1⅛th in. Food-plant, *Hibiscus tiliaceus,* Linn.

Also 6 ♂♂ in the B.M. collection, from Tahiti (*J. J. Walker* and *G. F. Mathew*).

32. **Anticarsia irrorata,** Fabr.

Noctua irrorata, Fabr., Spec. Ins., Append. ii, p. 506 (1781).

Society Islands.

Tahiti. 3 ♂♂, 1 ♀ beaten from herbage, Papeete, 21.ii. and 5.iii.25; 1 ♂ at light, 300 ft., Fautaua Valley, 24.ii.25; 1 ♀ at light on ship in Papeete harbour, 18.ii.25; 1 ♀, 2000 ft. (*L. E. Cheesman*); 1 ♀, Fautaua Valley, March 1925 (*L. E. C.*); 1 ♀, 26.iv.25 (*L. E. C.*); 1 ♀ in grass, 2000 ft., 17.iv.25 (*L. E. C.*); 1 ♀, 2000 ft., Val d'St. Amelie, 5.v.25 (*L. E. C.*).

Moorea. 1 ♀ beaten from herbage, 13.iii.25.

Raiatea. 1 ♀, 1500 ft., N. of island, 29.v.25 (*L. E. C.*); 1 ♀, sea-level, N. of island, 30.v.25 (*L. E. C.*).

Rapa Island.

3 ♂♂, 1 ♀ at light, near sea-level, 11 and 14.iv.25; 2 ♂♂, 5 ♀♀ flying among herbage by day, 15.iv.25.

Also specimens in the B.M. collection from Fatu Hiva and Nuka Hiva (*J. J. Walker*); and Tahiti (*J. J. W.* and *M. J. Nicoll*).

Hypeninae.

33. **Simplicia caeneusalis,** Walk.

Sophronia ? caeneusalis, Walk., List Lep. Ins. B.M., xvi, p. 94 (1858).

Marquesas.

Hiva Oa. 7 ♂♂, 8 ♀♀ at light, 1200 ft., 3.i.25.

Austral Islands.

Rurutu. 4 ♀♀ at light, 400 ft., 24.iii.25.

Rapa Island.

1 ♂, 1 ♀ at light, 14.iv.25.

Also 3 ♂♂ in the B.M. collection, from Tahiti (*J. J. Walker*).

34. **Hydrillodes melanozona,** sp. n.

(Plate XXI, fig. 6.)

♂. Head, thorax and palpus bistre; palpus sickle-shaped, the 2nd segment curved over the head, the 3rd rather long and tipped with cartridge buff, both segments with slight fringe of hair behind; antenna serrate fasciculate; abdomen snuff brown, with a patch of raised honey-yellow scales laterally on 1st segment, followed on 2nd segment by a large patch of blackish iridescent scales; legs bistre, tarsal joints and tips of spurs cartridge buff, fore tibia fringed with hair. Fore-wing bistre; an antemedial cartridge buff spot on costa and a second spot on costa above discocellulars; a fuscous antemedial fascia, crenate (concavities basad); a fuscous discocellular striga; an indistinct fuscous medial shade; a postmedial fuscous fascia, outwardly oblique to vein *R5*, thence dentate to inner margin, defined distally with cream buff, and with a cartridge buff spot on the costa; a series of cartridge buff subterminal neural spots, parallel to the postmedial fascia, and terminating with a more prominent spot on the costa; some cartridge buff irroration beyond the subterminal, especially in the apical area, and a series of fuscous interneural terminal spots; fringe bistre. Hind-wing buffy brown irrorated with fuscous; a faint discocellular striga and medial fascia indicated by an increase in the irroration; a faint postmedial fascia accentuated by a decrease in the irroration; fringe buffy brown. Underside of fore-wing buffy brown, the costal area slightly irrorated with cartridge buff and with four prominent cartridge

buff spots on the costal margin; cartridge buff postmedial and subterminal fasciae prominent at costa, becoming obsolescent. Underside of hind-wing cartridge buff, heavily irrorated with bistre, and with a discocellular striga and broad dentate postmedial and subterminal fasciae, indicated by an increase in the irroration.

♀. Very similar, but without fringes on palpus; antenna with fine short bristles; the black lateral patches on the abdomen much reduced, and the cartridge buff spots on the costa of the fore-wing only slightly indicated.

Expanse: ♂♂ 27–31 mm., ♀♀ 28–31 mm.

Rapa Island.

1 ♂ (holotype) and 1 ♀ (allotype) at light, 800 ft., 15.iv.25; also 6 ♂♂ and 4 ♀♀ at light, 800 ft., 15 and 17.iv.25; and 1 ♂ at light, sea-level, 11.iv.25.

35. **Hydrillodes crispipalpus**, sp. n.

(Plate XXI, fig. 5.)

♂. Head and thorax bistre; palpus sickle-shaped, the 2nd segment curved over the head, bistre for basal two-thirds and shading off to cream buff, the 3rd segment cream buff, rather long and wavy, and both segments with fringe of hair behind; antenna serrate fasciculate, the fascicles very long; abdomen snuff brown; legs bistre, tarsal joints and tips of spurs cartridge buff, fore tibia fringed with hair. Fore-wing bistre with hyssop violet reflections; a fuscous discocellular striga; a postmedial cream buff spot on costa; a cream buff subterminal fascia, outwardly oblique to vein *M*1 and thereafter indicated by a cream buff spot on each vein to inner margin; a series of preterminal cream buff spots, placed interneurally; fringe fuscous. Hind-wing, including fringe, Saccardo's umber; a fuscous discocellular striga; terminal line buffy brown. Underside of fore-wing buffy brown, the costal area slightly irrorated with cartridge buff; a postmedial outwardly oblique fuscous striga from costa to vein *M*1, thickened near costal margin and bordered distally with cream buff; a cartridge buff subterminal fascia. Underside of hind-wing cream buff, heavily irrorated with bistre, with a discocellular striga, an irregular postmedial and a dentate subterminal fascia, indicated by an increase in the irroration, the subterminal accentuated by light buff edging distally.

Expanse: 34 mm.

Society Islands.

Tahiti. 1 ♂ (holotype) and 1 ♂ (paratype) at light, 2500 ft., Fautaua Valley, 13.iii.25.

36. **Hypena walkeri**, sp. n.

(Plate XXI, fig. 9.)

♀. Head, thorax and antenna buffy brown, frontal tuft slight (in the type perhaps worn down). Palpus buffy brown, the 2nd segment long and porrect, and thickly clothed with long hair above, the 3rd segment somewhat upturned, clothed with moderately long hair above, and with the tip cream buff and naked; pectus and legs buffy brown, lightly irrorated with bistre, tibiae only slightly hairy; abdomen buffy brown, more heavily irrorated with bistre, and with light hyssop violet iridescence dorsally; basal tuft slight (in the type perhaps worn down). Fore-wing buffy brown, irrorated, especially in basal third, with darker scales having a light hyssop violet iridescence; a broad medial shade of velvety Brussels brown, from just before upper angle of cell, somewhat inwardly oblique to inner margin; a broad and irregular postmedial shade of velvety Brussels brown, roughly parallel with termen to vein *Cu*2, thence incurved (concavity tornad) to inner margin; preterminal area irrorated with olive brown; fringe olive brown. Hind-wing buffy brown, fringe olive brown. Underside of both wings buffy brown, including the fringe, which has a basal

line of Brussels brown; hind-wing with a faintly indicated slightly darker discocellular spot and postmedial and preterminal fasciae.

Expanse: 29 mm.

1 ♀ (holotype), slightly worn, in the B.M. collection, previously undescribed, taken by Commander J. J. Walker in Tahiti, in 1883. The species is not represented in the "St. George" collection.

37. **Hypena longfieldae,** sp. n.

(Plate XXI, fig. 11.)

♂. Head and thorax olive brown, scales and hairs tipped with buffy brown; frontal tuft olive brown above, fuscous beneath, irrorated with whitish; palpus fuscous, irrorated and tipped with whitish, the 2nd segment porrect and clothed with long hair, the 3rd upturned and hairy for two-thirds its length, the apex naked; pectus and legs snuff brown, fore and mid tibiae darker in front and moderately haired; abdomen olive brown dorsally, snuff brown ventrally, dorsal tufts on 1st two segments blackish. Fore-wing olive brown, with light hyssop violet reflections; a small raised tuft of velvety bistre scales near base of cell; an outwardly oblique antemedial striga from costa to above orbicular; postmedial fascia velvety bistre, edged distally with cream buff, inwardly oblique from costa to reniform, and thereafter broadening into a prominent somewhat three cornered area of velvety bistre (varying in shape in some specimens), its lower point reaching vein *Cu*2, its distal edge incurved (concavity tornad) and defined by cream buff, its upper edge reaching almost to orbicular; orbicular and reniform each with a tuft of raised scales of velvety bistre, the latter defined outwardly by cream buff; several light points on costa beyond postmedial; two subterminal velvety bistre spots, edged distally with whitish, between veins *R*4 and *R*5, and *R*5 and *M*1; in the type and some other specimens these two spots form part of a faint sinuous subterminal fascia composed of light and dark scales; a triangular terminal area of velvety fuscous black, its base on vein *M*2, its distal boundary following the termen and its proximal boundary running from vein *R*5 to vein *M*2, the proximal angle reaching almost to the subterminal fascia, and a band of the same colour running from this angle, above vein *M*2, to halfway between postmedial and subterminal fasciae; apical area irrorated with whitish; terminal line and fringe bistre, the fringe olive brown at base, with two similarly coloured lines through it, and chequered distally and interneurally with olive brown. Hind-wing olive brown, with dark greenish-glaucous reflections in costal area; terminal line and fringe as in fore-wing. Underside of both wings olive brown, the hind-wing and costal area of fore-wing irrorated with light to cream buff; veins defined with slightly darker scales; a conspicuous subterminal cartridge buff spot in fore-wing between veins *R*4 and *R*5, edged proximally with a few dark scales; a faint dark postmedial fascia on both wings, not continued to inner margins; terminal line and fringe as on upperside.

♀. Similar, but with shorter hair on fore and mid tibiae.

Expanse: ♂♂ 30–34 mm., ♀♀ 31–33 mm.

MARQUESAS.

Hiva Oa. 1 ♂ beaten from herbage, Mt. Temetio, 2500 ft., 31.xii.24.

RAPA ISLAND.

1 ♂ (holotype) and 1 ♀ (allotype) at light, 800 ft., 15.iv.25; also 3 ♂♂, 1 ♀ at light, 800 ft., 15 and 17.iv.25.

38. **Hypena sanctigeorgii,** sp. n.

(Plate XXI, fig. 10.)

♂. Head and thorax Brussels brown, scales and hair-scales tipped with buffy brown; frontal tuft and palpus raw umber, the latter with 2nd segment long and porrect, strongly

irrorated with tawny olive, the 3rd segment somewhat upturned and tipped with cartridge buff; pectus, legs and ventral surface of abdomen tawny olive; abdomen dorsally Brussels brown, the tufts on first two segments small. Fore-wing Brussels brown; a faint dark antemedial streak from cell to vein *A*2, inwardly oblique; a slightly raised tuft of blackish scales in the cell; postmedial fascia raw umber, edged distally with white and proximally with tawny olive, inwardly oblique to upper angle of cell, then slightly incurved to vein *Cu*2 (convexity basad), and more strongly incurved (concavity tornad) to inner margin; several light points beyond it on costa; a dark subterminal spot faintly indicated between veins *R*4 and *R*5, and another between *R*5 and *M*1; a series of faint black terminal points, placed internecurally; fringe Brussels brown. Hind-wing Brussels brown; fringe tawny olive, marked at regular intervals with patches of Brussels brown. Underside of both wings tawny olive, costal area of fore-wing lighter, with an interrupted blackish line along costa for distal one-third; a dark spot on discocellulars of hind-wing, a faint postmedial shade on both wings, and a light spot in apical area of fore-wing; a blackish terminal line on both wings.

♀. Similar.

Expanse: ♂♂ 39–41 mm., ♀ 40 mm.

Somewhat resembles the dark forms of *Hypena proboscidalis*, Linn., from which variable species it can be distinguished by the presence of white in the postmedial fascia, and the lack of light irroration over the fore-wings. In *H. proboscidalis* the postmedial fascia is more oblique.

Marquesas.

Hiva Oa. 1 ♂ (holotype) beaten from herbage, Mt. Temetio, 3000–3500 ft., 27.i.25; 1 ♂ (paratype), 1 ♀ (allotype) at light, Mt. Temetio, 3500 ft., 28.i.25.

Genus **Fautaua** nov.

Proboscis fully developed; palpus upcurved, the 2nd segment reaching above vertex of head and fringed with hair behind, the 3rd segment long and also fringed with hair behind; frons with tuft of hair above; eye large, round; antenna of male serrate fasciculate; abdomen with dorsal tuft on first segment; tibiae smoothly scaled; apex of fore-wing acute and produced, the termen excised below apex and excurved at middle; vein *Cu*1 from well before angle of cell, *M*2 from just above angle, *M*1 from just below upper angle, *R*2, 3, 4, 5 stalked, *R*1 from cell; hind-wing with veins *Cu*1 and *M*3 shortly stalked, *M*2 from just above angle of cell, discocellular almost obsolescent, *M*1 and *Rs* shortly stalked, *Sc* anastomosing with cell near base only.

Resembles in neuration *Ilyrgis*, which Hampson has placed in the Ophiderinae. Whilst it differs from *Ilyrgis* in several respects (*e.g.* palpi, general structure of the genitalia, etc.), it does not appear to agree with any other genus of Ophiderinae, and seems to fit better into the Hypeninae, where, however, no genus could be found to accommodate it, hence the erection of a new genus on somewhat slender grounds.

Type *F. diagonalis*.

39. **Fautaua diagonalis**, sp. n.

(Plate XXI, fig. 7.)

♂. Head and thorax, palpus, antennal shaft, legs and abdomen, clove brown; palpus with 2nd segment curved and reaching above vertex of head, the 3rd segment long and upturned, 2nd segment fringed with hair behind, the 3rd also; 1st segment of fore tarsus fringed with long hair in front; antenna serrate fasciculate. Fore-wing clove brown, with

deep lavender reflections; a diffused inwardly oblique fuscous shade from postmedial area of costa to lower angle of cell, and thence slightly more oblique to medial area of inner margin; fringe clove brown. Hind-wing snuff brown; a faintly indicated postmedial shade running parallel with termen; fringe snuff brown. Underside of both wings snuff brown.

Expanse: 27–28 mm.

SOCIETY ISLANDS.

Tahiti. 2 ♂♂ (holotype and paratype), at light, 1500 ft., Fautaua Valley, 16,iii.25; also 1 ♂ (paratype), at light, 2500 ft., Fautaua Valley, 13.iii.25.

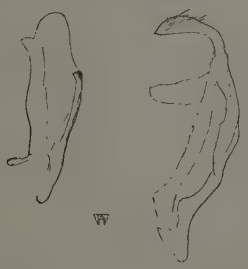


FIG. 2.—Male genital armature of *Fautaua diagonalis*.
Valve on left. Tegumen on right; lateral view, showing uncus.

40. **Fautaua innupta**, sp. n.

(Plate XXI, fig. 8.)

♀. Head, thorax, antenna and abdomen Prout's brown, the frontal tuft moderately developed and irrorated with whitish; antenna ciliate with fine short bristles; palpus with 2nd segment buffy brown, curved, reaching above vertex of head, and fringed with moderately long hair behind; 3rd segment Prout's brown, long and upturned, the extremity tipped with buffy brown, and with a slight fringe behind; legs buffy brown, with slight tufts of hair at end of tibiae. Fore-wing benzo brown; antemedial fascia Prout's brown, almost straight, and perpendicular to 2nd anal vein; a broad medial shade, Prout's brown, parallel to antemedial fascia; postmedial fascia buffy brown, excurved from costa to vein *Cu*1 (concavity basad), thence inwardly oblique to inner margin; three well-defined subterminal cartridge buff spots, one between *R*4 and *R*5, another slightly terminad between *R*5 and *M*1, the third more basad between *M*1 and *M*2. Hind-wing cartridge buff irrorated with fuscous; a faint postmedial fascia indicated by an increase of the irroration along its course; and a subterminal fascia, irregular and slightly waved, indicated by a decrease of the irroration, and running from the costal margin, gradually nearing the termen, and finishing at the tornus. Underside of both wings cartridge buff, irrorated with fuscous, and with the postmedial fascia on fore-wing and the two fasciae on the hind-wing as on upperside; three subterminal pale spots on the fore-wing also as on upperside, with a series of interneural white spots continued to inner margin.

Expanse: 25 mm.

SOCIETY ISLANDS.

Tahiti. 1 ♀ (holotype) at light, 1500 ft., Fautaua Valley, 16.ii.25.

41. **Luceria oculalis**, Moore.

Rivula oculalis, Moore, P.Z.S. Lond., p. 614, 1877.

RAPA ISLAND.

1 ♂ beaten from herbage, 11.iv.25; 2 ♂♂, 5 ♀♀ at light, sea-level, 11, 12 and 14.iv.25.

HYBLAEINAE.

42. **Hyblaea puera,** Cram.

Phalaena Noctua puera, Cram., Pap. Exot., ii, p. 10 and index (1777).

MARQUESAS.
Hiva Oa. 1 ♂, 1 ♀ at light, 600 ft., 26 and 28.xii.24.

SPHINGIDAE.

ACHERONTIINAE.

43. **Herse convolvuli,** Linn.

Sphinx convolvuli, Linn., Syst. Nat., Ed. X, p. 490 (1758).

MARQUESAS.
Nuka Hiva. 1 ♀ at light, 300 ft., 22.i.25. The red metanotal and abdominal patches in this specimen, and in a ♀ from Tahiti in the B.M. collection, are replaced by warm buff.

Also 1 ♂, 2 ♀♀ from Tahiti in the B.M. collection (*M. J. Nicoll* and *J. J. Walker*); and 1 ♂, 1 ♀ from Moorea (*J. J. W.*).

PHILAMPELINAE.

44. **Chromis erotus eras,** Boisd.

Deilephila eras, Boisd., Voy. "Astrol.," Lep., p. 185 (1832).

MARQUESAS.
Hiva Oa. 2 ♀♀ at light on ship in harbour, 27.xii.24; 2 ♂♂ at light, 600 ft., 28–29.xii.24; 1 ♂, 1 ♀ at light, near sea-level, 1.i.25.
Tahuata. 1 ♀ at light on ship in harbour, 12.i.25; 1 ♀ at light, 500 ft., 10.i.25.
Nuka Hiva. 1 ♂ at light, near sea-level, 23.i.25.

TUAMOTUS.
Napuka. 1 ♂, 1 ♀ bred from larvae, Feb.–March 1925.

SOCIETY ISLANDS.
Tahiti. 2 ♀♀ at light, near sea-level, Papeete, 23.ii. and 12.iii.25.
Bora Bora. 1 ♀, near sea-level, 15.iv.25 (*L. E. Cheesman*).

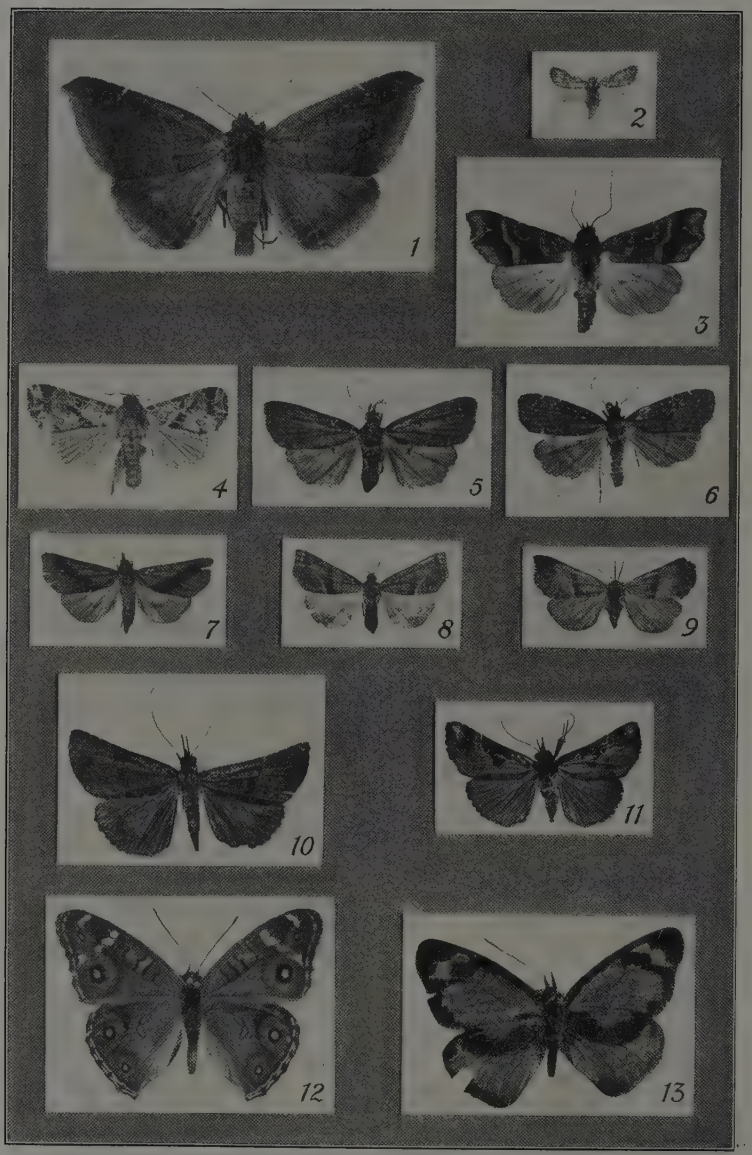
AUSTRAL ISLANDS.
Rurutu. 1 ♂ at light, 650 ft., 23.iii.25.
Larva. (Napuka.) Food-plant, *Morinda citrifolia*, Linn. Pupal stage, 18 days.

45. **Macroglossum hirundo hirundo,** Boisd.

Macroglossa hirundo, Boisd., Voy. "Astrol.," Lep., p. 184 (1832).

SOCIETY ISLANDS.
Tahiti. 1 ♂ at light, 1500 ft., Fautaua Valley, 16.iii.25.

Also in the B.M. collection from Tahiti, 4 ♂♂, 1 ♀ (*J. J. Walker*) and 1 ♂, 1 ♀ (*G. F. Mathew*), and from Moorea, 1 ♂ (*J. J. W.*).



Vaus & Crampton, Ltd.

NOCTUIDÆ AND RHOPALOCERA FROM FRENCH OCEANIA.

Chaerocampinae.

46. **Hippotion celerio,** Linn.

Sphinx celerio, Linn., Syst. Nat., Ed. X, p. 491 (1758).

Rapa Island.

3 ♂♂ bred from larvae. Pupated 16th, 22nd and 25th April, emerged 11th, 16th and 17th May, 1925. Food-plant, Taro, *Colocasia antiquorum,* Schott.

Also in the B.M. collection from Tahiti, 1 ♂, 1 ♀, and from Moorea, 1 ♂, 1♀ (*J. J. Walker*).

Explanation of Plate XXI.

All figures are natural size except Nos. 12 and 13, which are considerably enlarged.

Fig. 1. *Achaea marquesanus,* sp. n. ♂ type.
2. *Celama insularum,* sp. n. ♂ type.
3. *Callopistria ouria,* sp. n. ♂ type.
4. ,, *meridionalis,* sp. n. ♂ type.
5. *Hydrillodes crispipalpus,* sp. n. ♂ type.
6. ,, *melanozona,* sp. n. ♂ type.
7. *Fautaua diagonalis,* gen. et sp. n. ♂ type.
8. ,, *innupta,* gen. et sp. n. ♀ type.
9. *Hypena walkeri,* sp. n. ♀ type.
10. ,, *sanctigeorgii,* sp. n. ♂ type.
11. ,, *longfieldae,* sp. n. ♂ type.
12. *Precis villida longfieldae,* subsp. n. ♂ type (p. 458).
13. *Libythea collenettei,* sp. n. ♀ type (p. 456).

THE MICRO-LEPIDOPTERA OF THE "ST. GEORGE" EXPEDITION

By Edward Meyrick, B.A., F.R.S.

[Read October 3rd, 1928.]

In the *Transactions of the Entomological Society of London* for 1926, pp. 269–278, I discussed the Micro-Lepidoptera obtained during the "St. George" Expedition, 1924–5, from the Galapagos and the island of Rapa. In May of this present year the remainder of the Micro-Lepidoptera collected in other localities in the course of the same Expedition were also placed in my hands by the British Museum authorities; these have been investigated, and the results which are now set forth should be read in connection with those given in the previous paper quoted, which are not repeated here except where necessary. The types are preserved in the British Museum.

Over 1000 specimens were included in the present consignment, of which about two-thirds are from Pacific islands, the remaining third being from small islands closely adjacent to the American coast; these two sections are entirely unrelated, and are treated separately. The majority of the specimens were collected by Mr. C. L. Collenette and Miss C. E. Longfield, including all those where no captor is specially mentioned; but a proportion were taken by Miss L. E. Cheesman, and in the case of these her name is always recorded.

Disconnection of Polynesian and South American Faunas.

So far as the evidence goes, there is no trace whatever of any communication between these regions. The Marquesas are actually rather nearer to South America than to Australia, but the fauna of the Pacific islands is entirely of Indo-Malayan type. The fauna of the Galapagos is equally of pure American type, without a suspicion of Polynesian influence. Easter Island, so interesting from its peculiar position, unfortunately contributed no evidence at all, the single species taken there being a semi-domesticated insect of probably recent introduction. Special attention is due to the genus *Imma*, which is wholly tropical (precluding passage by Northern or Southern lands); the American species all belong to a particular (more primitive) section; from Fiji to the Marquesas nine species are now known, and all of these belong to the other section, and are of obvious Indo-Malayan type. Hence it appears that in such a case, the genus having originated in the Indo-Malayan region (where both sections are found), America can only have received its first representatives of the genus by way of Africa; and, in the absence of any evidence to the contrary, it must be assumed that the same explanation holds good for all similar cases. This is an important aid in tracing geographical distribution.

Polynesian Species.

Apart from Rapa and Easter Island, material was obtained from the Marquesas, Society, Paumotu (or Tuamotu), and Austral groups, numbering 67 species (or all included, 80). Of this total of 80, 24 occur in other Pacific islands or over a more extended range, and all these are probably to be accounted for by human transmission in comparatively recent times; the remaining 56 (including the Rapa species) are endemic. These may be analysed as follows:

30 belong to 2 genera, of which *Asymphorodes* (16) is wholly endemic, whilst *Dichelopa* (14) is only represented otherwise by 6 species in Eastern Australia.

3 belong to 3 monotypic endemic genera (*Nesoscopa*, *Microzestis*, *Nesoxena*).

3 species of the extensive tropical genus *Imma* are evidently modifications (but now structurally distinct) of a single original immigrant form.

4 species (besides 3 artificially spread, of which 2 are characteristically Pacific) represent *Decadarchis*, an Indo-Malayan genus also well represented in Fiji and Samoa.

8 belong to 4 cosmopolitan or Indo-Malayan genera (2 each, but not nearly inter-related), *Spilonota*, *Eucosma*, *Cosmopteryx*, *Gracilaria*.

8 are single representatives of 8 considerable or large cosmopolitan or Indo-Malayan genera, *Bactra*, *Argyroploce*, *Meridarchis*, *Orneodes*, *Simaethis*, *Zelleria*, *Parectopa*, *Tinea*.

Of these categories the last five comprise elements similar or identical in character with those found in the Western Pacific islands, but with the remarkable entire omission of the genus *Labdia*, which is far the largest genus found in them, being represented there by 36 species already known, almost all endemic, and also numerously in the Indo-Australian region. *Labdia* is also not found in Hawaii. On the other hand, the first category, including more than half the total number of species, is entirely peculiar, unconnected with the fauna of the Western Pacific on the one hand, and with that of Hawaii on the other. The considerable endemic development of the two peculiar genera *Dichelopa* and *Asymphorodes*—as explained in the remarks on the fauna of Rapa, I estimate the existing species to number not less than four times those actually captured in this brief visit, which would mean that each of these genera probably contains about 60 species—implies an extensive land-area not broken up by any very wide channels, and a long period of isolation to allow of the development of species. All the evidence now available therefore confirms and amplifies the conclusion expressed in the Rapa paper, and extends the limits of the presumed land-area to include the whole of this region of the Pacific, from Rapa to the Marquesas, and from Pitcairn Island to the Society and Cook groups. According to the "Times" Atlas, a rise of 12,000 feet in the sea-bottom would be sufficiently effective, converting all this area into an archipelago of large islands somewhat comparable in general form, trend, and extent with New Guinea and its surrounding groups as they exist at the present day. Its continued existence as a defined and isolated unit over a considerable period of time entitles it to a name for purposes of discussion, and if it has not previously obtained this recognition, I suggest that of Palaeonesia.

From a consideration of the circumstances and fauna of the Western Pacific islands, it would seem probable that these also are the reduced remains of a once more extensive land-area, which allowed easier communication between groups now widely separated. The degree of endemicity of their fauna is much lower, and the relationship to the existing Papuan fauna much nearer, than in the case of Palaeonesia. These features, together with the clearness of the line of demarcation, show plainly that the elevation of this area occurred at a different and much more recent period than that of Palaeonesia. At the time when this latter was at its highest point of development, the large and important genus *Labdia* probably existed only in its original home, India, and had not spread into eastern waters. Whilst this and the other principal constituents of their fauna probably reached the Western group by way of the Papuan region (not from Australia), the Palaeo-

nesian genera seem to have travelled by a more northerly route, and traces of their passage might perhaps be found in the Caroline and Marshall groups, if any survive; no evidence is at present available thence.

So far as appears from the groups of Lepidoptera included in this paper, Palaeonesia, which geographically occupies an intermediate position between Hawaii and New Zealand, though widely remote from both, contributes nothing at all to the explanation of the origin of the fauna of either. There is a well-marked though not extensive Papuan element in the fauna of New Zealand, but it is apparent that this travelled by way of the Western islands, at that comparatively recent period when they formed a more continuous land-area than at present; the connecting links are found on the path, and the specific development is, as might be expected, less than in the islands. Much the larger portion of the New Zealand fauna, however, came from America, and must have travelled, as appears from the map, directly across the Antarctic land-area, because there simply is no other route; which appears to prove that the South Pole was then differently situated, but probably also the Southern hemisphere relatively warmer than the Northern. I infer that the South Pole was shifted in the direction of Africa, which would involve shifting the North Pole in the direction of Siberia, and would make the British Isles and Greenland relatively warm regions, as in the Miocene period they appear to have been. The not inconsiderable generic and large specific development of this portion of the New Zealand fauna appears to me reasonably proportionate to such a date.

Only brief mention need be made here of the fauna of Hawaii, which would seem to be clearly also the eastern end of a former very long and narrow volcanic mountain range; its elements seem to have been accidentally selected and brought together by wind action over wide seas in long periods of time; in contrast with the other Pacific areas, much of it is certainly derived from America, but some of the most peculiar and ancient genera show no definite association with any particular fauna now existing elsewhere.

Pacific Islands Species.

Pterophoridae.

Marasmarcha pumilio, Zell.

Marquesas, Nuka Hiva (to 1000 feet), Hiva Oa, Tahuata, Fatu Hiva, January; Society Is., Tahiti (1500 feet), March (*Miss Cheesman*); Austral Is., Rurutu, 850 feet, March; 21 ex., some bred from larvae. Probably Indian in origin, but now occurs through most of the warmer regions of the world (including New Hebrides, Fiji, and Samoa), having been introduced with *Cajanus* and other *Leguminosae,* on which the larva feeds.

Tortricidae.

Dichelopa, Low.

This genus is specially characterised in the family by having veins 7 and 8 of the fore-wings stalked and both running to costa; in other genera usually, when 7 and 8 are stalked, 7 runs to termen. In the first four of the Rapa species, as in some of the Australian, 3 and 4 of the hind-wings are coincident (an unusual feature in the family); this is, however, not the case in any of the new species now described. The whole of the species agree well together in

type and general characters. The genus is probably a rather early form of the family, with some relation to *Peronea*.

Dichelopa honoranda, Meyr.

Rapa.

Dichelopa sericopis, Meyr.

Rapa.

Dichelopa deltozancla, Meyr.

Rapa.

Dichelopa ceramocausta, Meyr.

Rapa.

Dichelopa iochorda, Meyr.

Rapa.

Dichelopa argoschista, n. sp.

♂. 15–16 mm. Head, palpi rather dark fuscous. Thorax dark ferruginous-fuscous. Antennae serrulate, shortly ciliated (⅓). Fore-wings suboblong, costa anteriorly moderately arched, posteriorly nearly straight, apex obtuse, termen rounded, rather oblique; dark purple-fuscous; two oblique transverse silvery-white streaks margined deep ferruginous suffusion, from costa at ⅓ and ⅔, reaching about ¾ across wing, second attenuated: cilia grey, a darker subbasal shade. Hind-wings 3 and 4 connate; grey; cilia as in fore-wings.

Society Is., Tahiti, March, at light; 2 ex.

Dichelopa praestrigata, n. sp.

♂. 13–15 mm., ♀. 15–19 mm. Head, palpi, thorax dark brown, thorax sometimes suffused deep purplish. Antennae ♂ stout, shortly and evenly ciliated (⅓). Fore-wings suboblong, costa anteriorly moderately, posteriorly slightly arched, apex obtuse, termen rounded, somewhat oblique; brown or sometimes fuscous, variably tinged ochreous or ferruginous, strigulated or reticulated dark brown or dark fuscous; markings purple-brown or sometimes dark brown, edged dark brown or dark fuscous striae, these striae sometimes edged interiorly ferruginous and exteriorly light ochreous or yellowish; basal patch broad on dorsum, edge straight, oblique; central fascia moderately broad, narrowed on dorsum, oblique, anterior edge straight, posterior edge bent in middle or towards dorsum; costal patch represented by an excurved stria from costa beyond ⅔ to tornus, this and margin of central fascia sometimes curved together and connected before dorsum: cilia light brownish. Hind-wings 3 and 4 connate; grey; cilia grey.

Marquesas, Hiva Oa, 3500–4000 feet, January, mostly at light; 30 ex. Varies considerably.

Dichelopa dryomorpha, n. sp.

♂. 10–11 mm., ♀. 14 mm. Head, palpi, thorax dark brown. Antennae ♂ fasciculate-ciliated (2). Fore-wings moderate, costa anteriorly moderately arched, posteriorly nearly straight, apex rounded-obtuse, termen rounded, somewhat oblique; brown, with oblique transverse striae of deep purplish suffusion and some dark brown strigulation; markings dark brown; basal patch broad on dorsal half, with oblique edge, obsolete on costal half; central fascia moderately broad, oblique, somewhat narrowed towards costa, posterior edge somewhat prominent in middle; costal patch represented by an irregular fascia, darkest anteriorly and more or less undefined posteriorly, narrowed to termen above tornus: cilia

brownish-ochreous, tips pale. Hind-wings 3 and 4 connate; dark fuscous; cilia grey, a dark grey subbasal line.

MARQUESAS, Tahuata, January, beaten from herbage; 16 ex. Related to preceding, but differing notably in ciliations of ♂ antennae. The single ♀ is extremely worn.

Dichelopa exulcerata, Meyr.

Rapa.

Dichelopa peropaca, n. sp.

♂. 22 mm. Head, palpi, thorax dark brown. Antennae subdentate, fasciculate-ciliated (2). Fore-wings suboblong, costa anteriorly moderately, posteriorly hardly arched, apex obtuse, termen rounded, somewhat oblique; brown, strigulated dark fuscous; markings dark brown, strigulated dark fuscous; basal patch strongly marked, mixed yellow-brown on costa, edge oblique, rounded-prominent in middle and near dorsum; space between this and central fascia pale yellow-brown on costal third; central fascia rather broad, oblique, apical area beyond it almost wholly suffused dark brown, somewhat lighter-mixed in disc beyond central fascia, pale-dotted on costa: cilia rather dark brown, barred dark fuscous. Hind-wings 3 and 4 connate or very shortly stalked; grey obscurely mottled darker; cilia grey.

MARQUESAS, Fatu Hiva, 2000 feet, January, at light; 1 ex.

Dichelopa choleranthes, n. sp.

♂♀. 13–14 mm. Head grey-whitish, sides of crown ♂ grey. Palpi ♂ grey, tip whitish, ♀ whitish-grey. Antennae ♂ thinly fasciculate-ciliated (somewhat over 1). Thorax grey-whitish, shoulders grey, tegulae ♂ tinged ochreous. Fore-wings elongate, somewhat dilated, costa anteriorly gently arched, posteriorly nearly straight, apex obtuse, termen obliquely rounded; whitish-yellowish with slight greenish tinge, irregularly striated pale leaden-metallic, with scattered groups of small black scales between striae; markings formed by grey and coppery suffusion interruptedly edged blackish; basal patch with edge very oblique, extending on dorsum to middle; central fascia moderate, oblique, upper half darker and united with costal patch to form a triangular patch with paler centre on costa; a spot on middle of termen: cilia light grey, basal half whitish-yellow barred fuscous. Hind-wings 3 and 4 connate; grey; cilia light grey, a darker subbasal line.

MARQUESAS, Hiva Oa, 3500 feet, January, at light; 2 ex.

Dichelopa pachydmeta, n. sp.

♂♀. 10–11 mm. Head, thorax fuscous. Palpi dark fuscous, base and tip white. Fore-wings suboblong, costa anteriorly moderately, posteriorly hardly arched, apex obtuse-pointed, termen rounded, rather oblique; green-whitish; markings violet-fuscous mixed deep ferruginous, marked especially on edges with irregular interrupted black striae or strigulae; basal patch occupying $\frac{1}{5}$ of wing, edge nearly straight, direct; a fine irregular blackish striga midway between this and central fascia on dorsal half; central fascia broad, rather oblique, broadly connected on costa with a triangular patch occupying apex except terminal edge: cilia whitish-ochreous. Hind-wings rather dark grey; cilia light greyish, a darker subbasal line.

MARQUESAS, Hiva Oa, 3500–4000 feet, January, ♀ at light, ♂ beaten from herbage; 2 ex.

Dichelopa harmodes, n. sp.

♂♀. 14–16 mm. Head, palpi, thorax light greyish. Antennae ♂ fasciculate-ciliated (2). Fore-wings suboblong, costa anteriorly moderately arched, posteriorly nearly straight, apex obtuse, termen rather obliquely rounded; whitish irrorated grey, coarsely strigulated fuscous and dark fuscous; an irregular dark fuscous stria forming edge of basal patch, nearer base on dorsum than on costa, ♂ sometimes preceded by fuscous suffusion on costa; central fascia ♂ towards costa rather narrow, fuscous edged dark fuscous striae, anterior continued to below middle with some fuscous suffusion in disc, posterior short, ♀ hardly traceable; costal patch ♂ rather small, fuscous marked dark fuscous, ♀ obsolete: cilia grey-whitish, greyer towards base. Hind-wings 3 and 4 connate; grey, darker posteriorly; cilia light grey, darker towards base.

Marquesas, Nuka Hiva (2000 feet), Hiva Oa (3500 feet), Fatu Hiva (2000 feet), January, at light; 4 ex.

Dichelopa fulvistrigata, n. sp.

♂. 13–14 mm. Head, palpi, thorax pale ochreous-yellowish, palpi irrorated light brownish. Antennae fasciculate-ciliated ($2\frac{1}{2}$). Fore-wings suboblong, costa anteriorly moderately, posteriorly slightly arched, apex obtuse, termen slightly rounded, rather oblique; pale ochreous-yellowish, some slight fulvous irroration; markings deep fulvous, variably (in one example considerably, in the other very little) marked interiorly with irregular dark blue-leaden-grey blotches and fasciate streaks; basal patch mixed with ground-colour, broad on dorsum, edge oblique; central fascia moderate, oblique; costal patch represented by a slightly curved stria from costa beyond $\frac{2}{3}$ to termen above tornus and some irregular strigulation beyond this, connected by bar above middle with central fascia: cilia whitish-yellow (imperfect). Hind-wings 3 and 4 short-stalked; grey; cilia light grey, a darker subbasal shade.

Society Is., Tahiti, 1500 feet, at light, March; 2 ex.

Nesoscopa exsors, Meyr.

Rapa.

Eucosmidae.

Spilonota dilacerata, n. sp.

♂♀. 16–18 mm. Head white. Palpi white, base and an indistinct median ring of second joint blackish. Antennae ♂ with notch at about $\frac{1}{4}$. Thorax grey-whitish, some black spots towards shoulders, and a black posterior spot leaving extreme apex whitish. Fore-wings elongate, somewhat dilated, costa gently arched, ♂ with broad fold (enclosing whitish hairs) from base to middle, termen rounded, somewhat oblique; white, sometimes suffused light grey except costal edge; markings black; costa marked throughout with short oblique marks and strigulae, costal fold ♂ with six bars; an elongate spot on dorsum near base, beyond this a dorsal series of dots; an irregular blotch in disc before middle, in ♀ nearly reduced to a curved streak representing its lower edge; central fascia represented by a very irregular lobed spot in disc beyond middle connected with another on tornus; an irregular-triangular spot towards termen in middle, sometimes connected with tornal spot: cilia white, more or less barred blackish. Hind-wings whitish-grey, greyer towards termen; cilia grey-whitish, a light grey subbasal line.

Austral Is., Rurutu, 400–650 feet, March, at light; 9 ex. A distinct species, related to Indian forms.

Spilonota thyellopis, Meyr.

Rapa.

Spilonota holotephras, Meyr.

Marquesas, Nuka Hiva, Hiva Oa, Tahuata, up to 1200 feet, January, at light, and 4 bred from larvae found on guava by Miss Cheesman; Society Is., Tahiti, February; 19 ex. Occurs also in Fiji and Samoa, doubtless artificially spread with its food-plant.

Acroclita physalodes, Meyr.

Austral Is., Rurutu, 400–650 feet, March, at light; 20 ex. Occurs also in Fiji, Ceylon, Chagos Is., and Seychelles; the larva feeds on flower-buds of *Barringtonia*, and is introduced with it.

Crocidosema plebeiana, Zell.

Marquesas, Nuka Hiva, Hiva Oa, Tahuata, January; Society Is., Tahiti, Raiatea, April, May (*Miss Cheesman*); Austral Is., Rapa; 10 ex. A cosmopolitan species feeding on *Hibiscus* and other *Malvaceae*, with which it is introduced.

Eucosma agriochlora, n. sp.

♂. 17 mm. Head, palpi, thorax fuscous. Fore-wings moderate, somewhat dilated, costa gently arched, without fold, termen slightly rounded, rather oblique; reddish-fuscous, irrorated and suffusedly striated dark fuscous, costa alternately marked with grey-whitish irroration and dark fuscous; apical area beyond a line from $\frac{3}{5}$ of costa to tornus ochreous-whitish, on costa marked three small dark fuscous spots and one or two strigulae, a fine excurved fuscous stria from first costal spot to termen above tornus, a few scattered brownish and blackish scales or traces of strigulae in disc, two or three slight strigulae on termen: cilia whitish, ill-defined bars of dark fuscous irroration. Hind-wings 3 and 4 stalked; dark grey; cilia grey-whitish, a dark grey subbasal shade.

Marquesas, Nuka Hiva, January, at light; 1 ex.

Eucosma chaomorpha, n. sp.

♂. 15 mm., ♀. 18–22 mm. Head, palpi, thorax brown mixed fuscous and dark fuscous. Fore-wings moderate, somewhat dilated, costa gently arched, without fold, apex rounded-obtuse, termen slightly rounded, rather oblique; dark grey, sometimes somewhat mixed reddish-brown, with irregular transverse blackish-grey striae, and more or less irregularly irrorated whitish between these; costa blackish-fuscous with paired direct whitish strigulae: cilia grey mixed blackish and barred whitish. Hind-wings 3 and 4 stalked; grey, darker-mottled towards apex; cilia grey-whitish, a grey subbasal line.

Marquesas, Nuka Hiva, Hiva Oa, up to 300 feet, December, January, at light; 4 ex. The irregular distribution of the colouring appears to vary in each individual.

Bactra litigatrix, n. sp.

♂♀. 13–14 mm. Head ochreous-white. Palpi 2, whitish, partially slightly infuscated. Antennal ciliations ♂ $\frac{1}{2}$. Thorax whitish-ochreous. Fore-wings elongate, ♂ somewhat dilated, ♀ slightly, termen rather oblique, almost straight; whitish-ochreous; costa marked with short fine oblique dark fuscous strigulae, on posterior half with about four

oblique fuscous strigae from these; a fuscous median band from base to termen beneath apex more or less developed, in one ♀ entire, in other examples incomplete or irregularly interrupted; in ♂ some irregular oblique curved fuscous striae posteriorly, and some indistinct direct strigulae from dorsum: cilia whitish-ochreous, on termen with rows of dark fuscous points. Hind-wings ♂ grey-whitish, veins greyer, ♀ pale greyish; cilia grey-whitish, a greyer subbasal line.

Society Is., Tahiti, 2500 feet, March, at light (1 ♂, 1 ♀), Raiatea, May (1 ♀) (*Miss Cheesman*); 3 ex.

Argyroploce rhynchias, Meyr.

Marquesas, Hiva Oa, Tahuata, to 850 feet, January, at light; Society Is., Tahiti (to 1500 feet), Raiatea, March to May (*Miss Cheesman*); Austral Is., Rurutu, 400 feet, March; 7 ex. (all ♀). Occurs in India, Ceylon, and Mauritius; the larva feeds in fruits of *Canavalia*, and is introduced with these.

Argyroploce eumenica, n. sp.

♂. 19 mm. Head light grey, face darker violet-grey. Palpi subascending, violet-grey. Antennal ciliations fasciculated (1½). Thorax violet-brown, anterior edge grey. Fore-wings elongate, rather dilated, costa gently arched, apex obtuse, termen vertical, rounded beneath; greyish-purple, two or three ferruginous-brown strigulae; basal patch not darker, on costa strigulated black and reaching ⅓, on dorsum narrow and marked posteriorly with a subtriangular black spot suffused chestnut-brown above and preceded on dorsal edge by a white dot, edge curved above middle; space between this and central fascia forming a suffused white rhomboidal blotch on costa; central fascia somewhat oblique, chestnut-brown, broad and irregular-edged in disc, narrower and blackish-edged towards costa, rounded off beneath and not reaching dorsum, lower portion mixed dark fuscous; area beyond this chestnut-brown, five pairs of white strigulae on costa separated by dark fuscous and emitting blue-leaden-metallic striae which partially coalesce and cross wing, forming broad margins to ocellus, between these three short blackish dashes in ocellus and four others less marked and extended as fine lines posteriorly above these; some slight blackish and white strigulation on upper part of termen, and a blackish praemarginal dot below middle: cilia bronzy-grey, base fulvous, becoming pale violet on tornus. Hind-wings rounded-prominent on middle of termen and tornus, termen sinuate above and below middle; grey, towards apex suffused dark grey, costal area whitish; cilia whitish, a grey basal line.

Marquesas, Hiva Oa, 3500 feet, January, at light; 1 ex. Certainly allied to *aprobola*; it differs, however, structurally by the strong ciliations of antennae (in *aprobola* minute).

Argyroploce aprobola, Meyr.

Society Is., Tahiti, Raiatea, March to May (*Miss Cheesman*); Austral Is., Rurutu, Rapa, March; 33 ex. (besides 8 Rapa). Occurs throughout Indo-Malayan region to Seychelles and S. Pacific islands, feeding on various cultivated trees and shrubs, and imported with these.

Gelechiadae.

Phthorimaea operculella, Zell.

Marquesas, Hiva Oa, 3500–4000 feet, January; 2 ex. This nearly cosmopolitan pest of the potato is imported with its food-plant.

Platyedra gossypiella, Saund.

Society Is., Raiatea, May (*Miss Cheesman*); 2 ex. The equally notorious pest of the cotton-plant, introduced with it.

Stoeberhinus testacea, Butl.

Marquesas, Nuka Hiva, Hiva Oa, Fatu Hiva, Tahuata, up to 1500 feet, January; Society Is., Tahiti, Raiatea, May (*Miss Cheesman*); Austral Is., Rurutu, Rapa; Paumotus, Napuka, February; 174 ex. Occurs apparently throughout Polynesia, but not elsewhere; the larva feeds on dry vegetable refuse and is transported with it.

Autosticha pelodes, Meyr.

Marquesas, Nuka Hiva, Tahuata, January; Austral Is., Rapa, April; 3 ex. Also known from Celebes, Hawaii, and New Hebrides, doubtless Malayan in origin; the larva feeds on dead sticks and dry refuse.

Cosmopterygidae.

Cosmopteryx aphranassa, Meyr.

Rapa.

Cosmopteryx flavofasciata, Woll. (?).

Society Is., Raiatea, May (*Miss Cheesman*); 1 ex., 7 mm., without head or abdomen, basal half of fore-wings very rubbed, therefore indeterminable, but might be this species, which is nearly cosmopolitan in warm countries, being artificially spread (= *mimetis*, Meyr.).

Cosmopteryx melanarches, n. sp.

♀. 9 mm. (Head, thorax rubbed, palpi missing.) Antennae blackish, basal third whitish above, 3 apical joints white, then 4 black, 1 white, 1 black, 1 white. Fore-wings very narrow, long-caudate; black; a fine silvery-white line from base just beneath costa to $\frac{1}{3}$, then very oblique to $\frac{1}{4}$ (apparently also median and subdorsal lines not reaching base or band, this area injured); postmedian band black limited by narrow pale golden-metallic fasciae, anterior direct, entire but hardly reaching costa, posterior slightly inwards-oblique from costa, narrowly interrupted in disc, surmounted by white spot in cilia; a fine silvery-white line on termen from near fascia to apex: cilia dark grey, a silvery-white bar at apex. Hind-wings dark grey; cilia grey.

Society Is., Raiatea, May (*Miss Cheesman*); 1 ex.

Pyroderces incertulella, Walk.

Austral Is., Rurutu, 650 feet, March; 3 ex. I regard *tridigitella*, Wals., and *aulacosema*, Low., as merely representative forms of this species, which is then recorded as occurring in Queensland, Rapa, and Hawaii; the larva has been bred from flowers of *Pandanus*, but probably feeds also on various decaying vegetable refuse, as usual in the genus, and has been artificially spread by man. Walsingham erroneously referred this species to *Stagmatophora*.

Asymphorodes, n. g.

Head smooth; ocelli posterior; tongue developed. Antennae $\frac{4}{5}$, ♂ minutely ciliated, scape elongate, with pecten. Labial palpi very long, recurved, smooth, slender, terminal joint as long as or usually longer than second, acute. Maxillary palpi very short, filiform, appressed to tongue. Posterior tibiae shortly rough-haired above. Fore-wings elongate-lanceolate, 1*b* furcate, 2 from about $\frac{3}{4}$ of cell, 3 ♂ absent, ♀ normal or sometimes also absent, 6 from near 7 or out of 7 near base, 7 and 8 stalked, 7 to costa, 11 from or rather before middle. Hind-wings $\frac{2}{3}$, lanceolate, cilia 3; 2–5 nearly parallel, 6 and 7 stalked.

Type *valligera*. Probably correlated with *Limnoecia*.

Asymphorodes coesyrias, n. sp.

♀. 9–10 mm. Head, palpi, thorax yellow-whitish, tegulae sometimes brown. Antennae whitish ringed blackish. Fore-wings yellow-whitish or whitish-yellow; a small dark brown spot on base of costa; small semioval brown or dark brown spots on costa before and beyond middle; a brown apical patch more or less irrorated dark brown, its edge running from $\frac{3}{4}$ of costa to dorsum before tornus, rather curved: cilia fuscous. Hind-wings grey; cilia light grey.

Marquesas, Nuka Hiva, Hiva Oa, Tahuata, to 300 feet, December, January, at light; 9 ex.

Asymphorodes valligera, n. sp.

♂♀. 12–14 mm. Head, thorax whitish-ochreous-yellow, tegulae dark fuscous. Palpi ochreous-whitish. Fore-wings whitish-ochreous-yellow (in one ♀ deeper ochreous-yellow); markings dark fuscous, very variable; a straight-edged patch occupying basal $\frac{2}{5}$, ♂ sometimes including a costal spot of ground-colour, ♀ largely replaced by ground-colour except partial margins, also in one ♂ all yellow except posterior margin; a broad band occupying terminal third or more, including a semioval costal spot of ground-colour, sometimes also a suffused tornal or discal blotch, anterior edge sometimes with projection on fold: cilia whitish-ochreous-yellowish, sometimes suffused grey on tornal area. Hind-wings ♂ whitish-ochreous-grey, a dark grey thickened supramedian streak from base to middle, ♀ grey; cilia ♂ whitish-ochreous, ♀ greyish.

Marquesas, Hiva Oa, 3000–3500 feet, December, January, amongst herbage and at light; 15 ex.

Asymphorodes plectographa, n. sp.

♂. 10 mm. Head, thorax ochreous-whitish, face greyish, shoulders with a blackish spot. Palpi dark grey, apex of second joint, and basal third and apex of terminal joint whitish. Antennae dark grey. Fore-wings white, posteriorly tinged ochreous; markings black; a spot on base of costa, terminating in a very oblique wedge-shaped projection; some irregular markings towards dorsum on basal fourth; an elongate spot on costa at $\frac{2}{5}$; an irregular oblique streak from costa beyond middle, acutely angulated in disc and running to middle of dorsum, its angle preceded by more or less blackish suffusion; a small spot in disc beyond angle representing second discal stigma; an elongate blotch on costa about $\frac{3}{4}$, posteriorly emitting a slightly curved irregular streak to tornus, from this in disc a streak runs to apex: cilia whitish-yellowish, above apex suffused dark grey. Hind-wings grey; cilia light grey.

Marquesas, Hiva Oa, 3500 feet, January, at light; 1 ex.

Asymphorodes leucoterma, n. sp.

♀. 11 mm. Head ochreous-whitish, face greyish. Palpi blackish, apex of second joint and base and apex of terminal joint white. Antennae whitish ringed grey. Thorax and abdomen blackish-grey. Fore-wings blackish-grey; a small silvery-white basal spot; an ochreous-white mark on costa beyond middle; a rather irregular ochreous-white streak along termen: cilia ochreous-white, on costa blackish-grey. Hind-wings dark grey; cilia grey.

MARQUESAS, Hiva Oa, January, at light; 1 ex.

Asymphorodes circopis, n. sp.

♂♀. 11–12 mm. Head, thorax dark grey, face whitish-ochreous. Palpi ochreous-whitish, an incomplete almost apical ring of second joint and anterior edge of terminal joint dark grey. Antennae whitish ringed blackish, scape dark grey. Fore-wings basal half dark grey, edge straight or slightly bent on fold; remainder yellow-whitish, sometimes tinged grey posteriorly, enclosing a rather large round blackish-grey spot (second discal stigma) in disc at $\frac{3}{4}$, an elongate dark grey suffusion on costa above this and reaching it, and a blackish-grey mark on costa before apex: cilia whitish-grey, on costa greyer at base and ochreous-whitish between dark markings. Hind-wings and cilia light grey.

MARQUESAS, Nuka Hiva, 1500 feet, January, beaten from tree and at light; 3 ex.

Asymphorodes sphenocopa, n. sp.

♀. 7–8 mm. Head pale ochreous, sides white. Palpi whitish. Antennae whitish, ringed grey. Thorax pale ochreous. Fore-wings 4 absent; whitish-ochreous; obscure brownish-ochreous very oblique wedge-shaped streaks from costa at base, $\frac{1}{4}$, middle, and beyond middle, and a median longitudinal streak from base to middle or beyond; second discal stigma minute, black; an irregular brownish patch in disc posteriorly extended to costa, and an irregular streak along lower part of termen; an elongate blackish spot on costa before apex; a minute blackish apical dot: cilia whitish-ochreous. Hind-wings grey; cilia pale grey.

MARQUESAS, Nuka Hiva, 200 feet, January, at light; 2 ex.

Asymphorodes phaeochorda, n. sp.

♂♀. 9–10 mm. Head, thorax whitish, tegulae fuscous, shoulders darker. Palpi whitish, anterior edge of terminal joint more or less infuscated, in one ♂ lower $\frac{2}{3}$ of second joint and apical half of terminal joint dark fuscous. Antennae whitish ringed dark fuscous. Fore-wings ochreous-whitish, sometimes with costal area or wholly tinged grey, darker posteriorly, or apical half wholly grey, but dorsal area usually whitish; usually a suffused fuscous median longitudinal streak from base to apex, plical and second discal stigmata forming moderate blackish spots on its lower edge and within it respectively, these always conspicuous, but streak sometimes obsolete in disc, especially in ♂, or reduced to small apical spot only, margined by white costal and terminal spots preceded by dark grey suffusion; seldom a short blackish dash beneath middle of costa, or (in 4 males) a strong black oblique streak from costa to second discal stigma: cilia whitish variably mixed grey, a blackish antemedian line round apex. Hind-wings pale grey; in ♂ a slender dark grey thickened longitudinal streak beneath median part of costa; cilia ochreous-whitish, sometimes tinged grey.

Marquesas, Nuka Hiva, Hiva Oa, Tahuata, Fatu Hiva, up to 1200 feet, January, at light; 35 ex. Remarkably variable, but the various forms taken together and intergrading, doubtless conspecific.

Asymphorodes nephocirca, n. sp.

♀. 9–11 mm. Head, thorax grey, face whitish-ochreous. Palpi ochreous-whitish, terminal joint dark grey anteriorly. Antennae ochreous-whitish. Fore-wings rather dark grey; stigmata rather large, cloudy, dark fuscous, first discal in middle of wing, plical beneath first discal, these sometimes edged whitish posteriorly, second discal rather near first, sometimes ringed whitish; a small cloudy whitish spot on costa towards apex; sometimes a minute whitish dot on termen just before this: cilia light grey, a suffused whitish spot at apex. Hind-wings grey; cilia light grey.

Marquesas, Tahuata, Hiva Oa, up to 800 feet, December, January, at light and beaten from herbage; 6 ex.

Asymphorodes myronota, n. sp.

♂♀. 9–11 mm. Head, thorax whitish-yellow, tegulae dark fuscous. Palpi ochreous-whitish, second joint pale fuscous except apex, terminal joint suffused fuscous anteriorly. Antennae whitish. Fore-wings dark fuscous; a light ochreous-yellowish dorsal stripe from base to tornus, attenuated at extremities; an elongate light ochreous-yellowish mark on costa beyond middle, and a semioval spot towards apex: cilia pale greyish, round apex and upper part of termen basal half rather dark fuscous spotted yellowish at base. Hind-wings and cilia pale greyish; ♂ beneath with long ochreous-whitish hair-pencil from beneath costa near base lying along cell to ⅔ of wing.

Marquesas, Hiva Oa, to 1200 feet, December, at light; 8 ex.

Asymphorodes interstincta, n. sp.

♀. 11 mm. Head, palpi, thorax ochreous-white, tegulae dark brown. Antennae white ringed dark fuscous. Fore-wings ochreous-white; discal area on basal fourth dark brown (leaving costa and dorsum broadly ochreous-white), beyond this irregularly sprinkled brown, the irroration posteriorly extending to margins; plical and second discal stigmata moderate, dark fuscous: cilia ochreous-whitish (apex of wing injured). Hind-wings light grey; cilia grey-whitish.

Paumotus, Fakarava, February, at light; 1 ex.

Asymphorodes polluta, n. sp.

♀. 12 mm. Head, thorax whitish-ochreous. Palpi, antennae ochreous-whitish. Fore-wings whitish-ochreous, becoming gradually infuscated posteriorly; stigmata dark fuscous, plical and first discal cloudy, elongate, plical obliquely posterior, second discal well-marked, moderately large; a small suffused dark fuscous apical spot: cilia whitish-ochreous, on costa fuscous, base on termen spotted fuscous. (Hind-wings missing.)

Marquesas, Hiva Oa, 3500 feet, January, at light; 1 ex. Notwithstanding defective condition, I venture to describe this as a quite recognisable species.

Asymphorodes cirsodes, n. sp.

♂. 14 mm. Head, thorax pale ochreous, tegulae dark fuscous. Palpi ochreous-whitish, second joint tinged fuscous on basal ⅔, terminal joint dark fuscous anteriorly.

Antennae ochreous-whitish barred dark fuscous above. Abdomen fuscous, basal half and anal tuft pale ochreous. Fore-wings dark purplish-fuscous; an irregular whitish-ochreous dorsal streak from base to tornus, attenuated at extremities, upper edge rather rounded-prominent opposite middle of wing: cilia fuscous, on tornal area whitish-ochreous. Hind-wings grey, lighter anteriorly; cilia whitish-ochreous, on costa greyish; on undersurface a long slender ochreous-whitish hair-pencil from beneath costa near base lying along cell and reaching to $\frac{2}{3}$ of wing.

MARQUESAS, Hiva Oa, 3500 feet, January, at light; 1 ex.

Asymphorodes porphyrarcha, n. sp.

♂♀. 12–14 mm. Head, thorax dark purple-fuscous, orbits yellow-ochreous. Palpi yellow-ochreous, terminal joint anteriorly dark fuscous. Antennae grey-whitish ringed dark fuscous, or wholly dark grey. Abdomen dark grey, anal tuft grey. Fore-wings deep purple: cilia dark grey. Hind-wings and cilia grey.

MARQUESAS, Hiva Oa, 3500 feet, January, at light or beaten from herbage; 6 ex.

Asymphorodes monoxesta, n. sp.

♂♀. 11–13 mm. Head, thorax greyish-ochreous or light fuscous, face glossy ochreous-whitish. Palpi whitish, a dark fuscous lateral line throughout. Antennae whitish ringed dark fuscous. Fore-wings greyish-ochreous or light fuscous, costal edge more or less tinged whitish from $\frac{1}{3}$ to near apex: cilia grey. Hind-wings grey-whitish, becoming grey towards apex; cilia grey, becoming ochreous-whitish round lower part of termen and dorsum.

SOCIETY IS., Tahiti, 500–2500 feet, March to May (*Miss Cheesman, Collenette*); 9 ex.

Asymphorodes acerba, n. sp.

♀. 9–10 mm. Head, thorax dark bronzy-grey. Palpi bronzy-grey, terminal joint white with anterior edge black. Antennae black ringed white, scape dark bronzy-grey. Fore-wings dark bronzy-grey; an indistinct dot of whitish suffusion on costa towards apex: cilia grey. Hind-wings and cilia grey.

MARQUESAS, Nuka Hiva, Fatu Hiva, January, at light; 2 ex.

Asymphorodes perfuga, Meyr.

Rapa. This species was attributed to *Ulochora*, but is properly referable here.

Microzestis, n. g.

Head smooth; ocelli posterior; tongue developed. Antennae ♀, ♂ serrulate, simple, scape elongate, without pecten. Labial palpi long, recurved, slender, second joint with appressed scales, terminal joint as long as second, acute. Maxillary palpi rudimentary. Posterior tibiae with loosely appressed hairs above. Fore-wings with small tufts of scales, 2 from angle, 3 absent, 4 and 5 approximated, 7 and 8 out of 6, 7 to costa, 11 from middle. Hind-wings $\frac{2}{3}$, narrow-lanceolate, cilia 4; 2–4 parallel, 4 and 5 approximated at base, 6 and 7 approximated at base.

Allied to *Leptozestis*.

Microzestis inelegans, n. sp.

♂♀. 5–7 mm. Head, thorax dark grey sprinkled whitish, face whitish. Palpi dark grey, apical ⅓ of second joint and subbasal band of terminal joint whitish. Fore-wings elongate-lanceolate; dark grey, bases of scales whitish forming a very fine transverse striolation; about 10 or 12 scattered irregular spots of blackish irroration, containing some raised scales; a small suffused white costal spot before apex: cilia grey, round apex tinged whitish and speckled black near base. Hind-wings grey; cilia light grey. Ovipositor ♀ large, spatulate.

Marquesas, Tahuata, Hiva Oa, to 850 feet, January, at light; 9 ex. The larvae would probably feed in the shoots of a Myrtaceous shrub.

Oecophoridae.

Bathraula simulatella, Walk.

Society Is., Tahiti, 1500 feet, March; 2 ex. Occurs also in Borneo, Philippines, and Bismarck Archipelago; the larval habits are not known, but the distribution shows that it is transported in some way by man.

Carposinidae.

Meridarchis pelograpta, n. sp.

♂. 14–16 mm., ♀. 16–19 mm. Head ochreous-whitish, sides of crown more ochreous, face whiter. Palpi ♂ 1½, subascending, ♀ 3, porrected, whitish, basal ⅔ of second joint dark fuscous. Antennal ciliations ♂ 4. Thorax whitish-ochreous more or less tinged brownish. Abdomen grey-whitish, usually appearing reddish-tinged. Fore-wings elongate, slightly dilated, costa slightly arched, termen straight, rather oblique; pale ochreous or pale greyish-ochreous, irregularly irrorated fuscous and dark fuscous, strewn with minute glittering whitish specks; eight irregular dark fuscous spots on costa, anteriorly more elongate; base narrowly suffused brown and dark fuscous; an undefined triangular patch of irregular dark fuscous marking resting on costal spots 3–6 and extending to fold, its apex truncate, two large tufts in disc preceding this and a small blackish mark between them; an undefined narrow subterminal fascia of dark brown suffusion; an interrupted suffused dark fuscous terminal line: cilia grey, basal half darker or suffusedly barred darker. Hind-wings light grey; cilia pale grey or whitish-grey.

Austral Is., Rurutu, 400–650 feet, March, at light; 25 ex. Allied to *zymota*, but larger and rather broader-winged, and with termen of fore-wings obviously less oblique.

Orneodidae.

Orneodes pselioxantha, n. sp.

♂. 12–14 mm. Head, thorax silvery-white. Palpi moderate, recurved, loosely scaled, white, terminal joint ⅔ of second. Antennae ochreous-whitish. Fore-wings silvery-whitish; two series of grey-yellowish suffused marks crossing segments near their base, two others excurved beyond their middle (in one specimen blackish-marked), a pale ochreous-yellowish narrow fascia between these, and another towards termen; grey dots near tips of segments, silvery-white dots at tips: cilia whitish, faint bars of yellowish suffusion on markings. Hind-wings whitish; seven series of yellow-ochreous dots or small spots speckled blackish-grey; cilia whitish, tinged yellowish on markings.

Paumotus, Fakarava, February, at light; 4 ex. Allied to *Hofmanni*, Pag., but distinct if the description is accurate.

GLYPHIPTERYGIDAE.

Imma chloroplintha, n. sp.

♂♀. 19 mm. Head, palpi, thorax whitish-ochreous, terminal joint of palpi ♂ ⅔, ♀ half second. Antennae ♂ dentate, fasciculate-ciliated (over 2). Posterior tibiae white, without hairs beneath. Fore-wings formed as in *semiclara*; whitish-ochreous-yellowish, ♀ irrorated light fuscous on basal half; an irregular posteriorly suffused dark fuscous line from costa beyond middle to dorsum at ¾, sinuate above and below middle, area beyond this fuscous, ♂ suffused whitish-yellowish towards termen; a terminal series of small dark fuscous triangular spots connected on edge, anteriorly edged whitish-yellowish suffusion, in ♀ these apparently obsolete: cilia fuscous. Hind-wings dark grey, costal ⅔ ochreous-whitish from base to near termen, forming an oblong patch; cilia ochreous-whitish, a grey basal shade.

SOCIETY IS., Tahiti, 1500–2500 feet, March, July (*Miss Cheesman, Collenette*); 2 ex.

Imma oxypselia, n. sp.

♂. 19–20 mm. Head, palpi, thorax whitish-ochreous, terminal joint of palpi half second. Antennae dentate, fasciculate-ciliated (somewhat over 2). Posterior tibiae beneath with long rough ochreous-whitish hairs. Fore-wings formed as in *semiclara*; whitish-grey-yellowish; a rather irregular yellow-whitish line from beyond middle of costa to dorsum at ⅔, edged posteriorly by a suffused fuscous line; a terminal series of small acute-triangular dark fuscous spots connected on edge, anteriorly edged yellow-whitish suffusion: cilia yellow-whitish. Hind-wings grey, terminal third suffused darker grey; cilia yellow-whitish, a greyish subbasal line.

SOCIETY IS., Raiatea, 500–1500 feet, May, June (*Miss Cheesman*); 3 ex.

Imma semiclara, n. sp.

♂♀. 18–21 mm. Head, palpi, thorax whitish-ochreous, terminal joint of palpi half second, thorax sometimes tinged greyish. Antennae ♂ flat-subdentate, ciliations somewhat over 1. Fore-wings moderate, posteriorly dilated, costa gently arched, termen rounded, little oblique; 7 and 8 stalked, 8 to termen; anterior half pale grey-yellowish limited by a narrow fascia of whitish-yellowish suffusion preceding a hardly curved rather dark fuscous line from costa beyond middle to dorsum at ⅔, posterior area beyond this light yellow-brownish, darker anteriorly and palest towards apex; a dark fuscous scalloped terminal line, slightly edged pale yellowish anteriorly: cilia pale greyish, base dotted pale yellowish. Hind-wings light grey, terminal third suffused dark grey; cilia yellow-whitish, a grey basal shade.

MARQUESAS, Nuka Hiva, Hiva Oa, Tahuata, December, January; 13 ex. Two large females are peculiar; one from Hiva Oa, 24 mm., has fore-wings uniform whitish-ochreous, transverse line only faintly indicated, terminal line distinct, hind-wings grey-whitish, towards termen grey; the other from Tahuata, 25 mm., has fore-wings uniform pale brownish-grey, transverse line distinct but fragmentary, terminal line distinct, hind-wings light grey, darker towards termen; probably these are only exceptional variations; the other females, however, seven in number, do not differ at all in size or colouring from the males.

Simaethis chelaspis, n. sp.

♂♀. 14–16 mm. Head grey speckled white. Palpi clothed with about 8 or more whorls of dark grey white-tipped scales projecting in front with long rough scales diminishing to apex. Antennae white ringed black, ciliations ♂ 4. Thorax bronzy-grey, some whitish speckling posteriorly, tegulae edged whitish speckling. Fore-wings triangular, costa moderately arched, termen slightly rounded, rather oblique; 7 and 8 approximated or seldom short-stalked; ochreous variably tinged or partially obscured grey; a slightly curved violet-blue-leaden metallic grey-edged streak from near base above middle to $\frac{1}{3}$; anterior half of dorsum suffused grey, some whitish speckling at base; a straight grey-edged fascia of close whitish irroration at $\frac{1}{3}$, and an angulated fascia at $\frac{2}{3}$, dilated towards dorsum, both interrupted by supramedian streak, a small blue-leaden-metallic spot preceding second below middle; immediately beyond second an oval black blotch resting on tornus and reaching half across wing, crossed by a sinuate transverse whitish line with two linear projections posteriorly and a short one anteriorly; a violet-leaden-metallic grey-edged streak from beneath middle of costa near apical and terminal margins and limiting this blotch to tornus: cilia shining grey, a fine dark grey basal line. Hind-wings rather dark grey; an ochreous terminal streak varying in width, seldom an obscure ochreous longitudinal streak in disc and subterminal streak of pale irroration on dorsal half; cilia grey, whitish-tinged towards base, a dark grey basal line.

Marquesas, all Hiva Oa, December, at light, except 1, Fatu Hiva, 2000 feet; 58 ex.

Simaethis chalcotoxa, Meyr.

Society Is., Bora-Bora, June, 500 feet (*Miss Cheesman*); 3 ex. Also occurs in Tonga and Fiji; probably attached to a cultivated *Ficus* and transported with it.

Simaethis orthogona, Meyr.

Society Is., Tahiti (to 2500 feet), Bora-Bora (to 500 feet), February, March, June, August (*Miss Cheesman, Collenette*). Occurs from India and Ceylon to New Guinea and Queensland; larva feeding on *Streblus* (*Moraceae*), with which it is presumably introduced.

Hyponomeutidae.

Zelleria leucostrota, n. sp.

♂♀. 15–16 mm. Head white. Palpi dark fuscous, apex white, terminal joint rather stout, smooth. Thorax grey sprinkled white. Fore-wings elongate, rather narrow, costa gently arched, apex pointed, termen straight, extremely oblique; fuscous closely irrorated white, some irregularly scattered small black dots; a white dot in disc at $\frac{3}{4}$, beneath it a small elongate blackish mark, from this an oblique streak of white suffusion extends to costa towards apex; apex suffused dark fuscous irroration: cilia pale greyish with rows of blackish points, above apex with two blackish shades. Hind-wings and cilia grey.

Marquesas, Nuka Hiva, Tahuata, 200–850 feet and one at 3500 feet, January, at light; 4 ex. Near *strophaea* from Ceylon, but obviously broader-winged.

Gracilariadae.

Epicephala colymbetella, Meyr.

Marquesas, Nuka Hiva, 100 feet, January, at light; 1 ex. An Eastern Australian species of which the larval habits are unknown, but probably attached to some cultivated tree.

Parectopa pontificalis, n. sp.

♀. 10–11 mm. Head pale yellow, face white with crimson marks on sides. Palpi whitish, second joint crimson, scales roughened beneath and shortly projecting at apex, terminal joint twice second. Thorax crimson, posterior half yellow except extremity. Abdomen whitish, a lateral series of oblique grey marks. Fore-wings very narrow, shortly obtuse-pointed; yellow; base narrowly crimson, whence a moderate crimson streak extends along basal fifth of costa, then obliquely to dorsum, again angulated upwards and continued through disc with two bars to dorsum, terminating in a crimson patch occupying apical fifth of wing, thus enclosing four yellow dorsal blotches, of which first is trapezoidal, others semioval or triangular; extreme costal edge white on yellow area, in one example with two crimson dots; a dark fuscous streak occupying upper edge of crimson streak from about middle of wing to apical patch; a small round black spot in apical patch before apex, a small black dot on costa before this preceded and followed by pale yellow suffusion, and a yellow dot beneath it on termen: cilia pale yellow, at apex with two crimson hooks, on tornus greyish. Hind-wings grey; cilia grey-whitish, greyer round apex.

Austral Is., Rurutu, up to 650 feet, March; 3 ex. This approaches still nearer than the Samoan *pyrelictis* to the New Zealand *miniella*.

Gracilaria hilaropis, Meyr.

Rapa.

Gracilaria crypsidelta, Meyr.

Rapa.

Lyonetiadae.

Opogona aurisquamosa, Butl.

Society Is., Tahiti, April (*Miss Cheesman*); Easter I., May, flying by day; 5 ex. Also recorded from Hawaii, the Marquesas, Fiji, and Kermadec Is.; larva feeding on dead leaves, dead wood, cotton bolls, etc., artificially transported.

Pisistrata trypheropa, Meyr.

Society Is., Tahiti (1500 feet), Raiatea, March, May (*Miss Cheesman*); 4 ex. Described from Samoa, where it is common; habits unknown, but larva probably feeding on some kind of vegetable refuse.

Erechthias flavistriata, Wals.

Marquesas, Fatu Hiva, January; 1 ex. Also occurs in Hawaii, Fiji, Java, and Malaya; larva feeding on dead stems and leaves, also on flowers of *Cocos nucifera*.

Erechthias zebrina, Butl.

Society Is., Raiatea, May (*Miss Cheesman*); 1 ex. Now practically cosmopolitan in hot countries; larva on dried vegetable substances.

Decadarchis minuscula, Wals.

Marquesas, Nuka Hiva, January, at light; 1 ex. Also generally distributed in hot countries; larva in dried stems, pods, leaves, etc.

Decadarchis pelotricha, Meyr.

Society Is., Tahiti, to 1500 feet, February, March, at light, 3 ex. (2 ♂, 1 ♀); also a very worn ♂ without palpi from Raiatea is probably the same species; described originally from Rapa.

Decadarchis clistopa, n. sp.

♂. 15 mm. Head, thorax pale grey irrorated white. Palpi grey irrorated white, beneath with long rough projecting scales throughout. Fore-wings elongate, costa gently arched, termen very obliquely rounded; light grey closely speckled white; basal fifth of costa suffused dark grey; some grey antemedian suffusion along costa, and a mark in disc above middle; plical and second discal stigmata represented by short blackish linear marks; a fine dark grey line just beneath costal edge on apical third, some grey suffusion beneath anterior end of this; a fine dark grey terminal line suffusedly expanded at apex and tornus; cilia whitish-grey somewhat mixed dark grey. Hind-wings 5 and 6 stalked; light grey; cilia ochreous-whitish, base grey.

Marquesas, Nuka Hiva, 100 feet, January, at light; 1 ex.

Decadarchis psammaula, Meyr.

Austral Is., Rurutu, 400–650 feet, March, at light; 3 ex. Also recorded from Fiji and Tahiti; larva on leaves of *Cocos nucifera*.

Decadarchis sphenacma, Meyr.

Rapa.

Decadarchis physocapna, n. sp.

♂. 15 mm. Head whitish-ochreous. Palpi ochreous-whitish, mixed dark fuscous towards base, beneath with rough projecting whitish hairscales throughout. Thorax fuscous, shoulders dark fuscous. Fore-wings elongate, costa gently arched, termen very obliquely rounded; pale ochreous, posteriorly somewhat sprinkled light fuscous; base of costa suffused dark fuscous; a strong suffused dark fuscous submedian streak from base to ⅔, its apex enlarged above into a transverse blotch expanding upwards and terminating in two arms on costa at about middle and ⅔; a dark fuscous apical spot (cilia denuded). Hind-wings 5 and 6 stalked; light grey; cilia pale grey.

Marquesas, Hiva Oa, 1200 feet, January, at light; 1 ex.

Decadarchis simulans, Butl.

Marquesas, Tahuata, 700 feet, bred from larvae; Society Is., Raiatea, May (*Miss Cheesman*); 16 ex. Larva described as cream-yellow, legs and prolegs dark yellow, head pale brown; feeding under bark of a dead tree, surrounded by mass of silk, wood-dust, and excrement; pupates in cocoon in same situation; found January, 13 moths bred February. Occurs throughout the Pacific islands from Hawaii to Fiji, also in Queensland and East Africa, artificially transported. I find that *decaspila*, Low. (a name applied to the Australian form), cannot be regarded as a distinct species, some Pacific specimens being exactly similar.

Tineidae.

Nesoxena, n. g.

Head smooth; tongue absent. Antennae probably 1 (broken), joints closely set, simple, scape moderate, stout. Labial palpi very long, second joint long, porrected, with

rough projecting scales above, terminal joint shorter than second, slender, pointed. Maxillary palpi moderately long, filiform, several-jointed, folded. Fore-wings 1*b* furcate, cell very long, reaching ¾, lower margin arched upwards, 2 from near angle, 3 and 4 approximated from angle, 7 and 8 short-stalked, 7 to costa, 9 and 10 from towards angle, accessory cell tolerably distinct, 11 from before middle; retinaculum chitinous, bar-shaped. Hind-wings 1, elongate-ovate; cell short, not reaching middle, narrow, margins sinuate at base, 2 almost from base, 3 and 4 very long-stalked or coincident from angle, cell very narrowly open between 3 and 5, 5 sinuate towards base, 6 and 7 almost connate, 6 to apex, 8 long and near 7 throughout.

Probably related to *Coryptilum*, but a remarkable form.

Nesoxena strangulata, n. sp.

♂. 15 mm. Head, thorax white. Fore-wings elongate, costa moderately arched, apex obtuse, termen very obliquely rounded; white. Hind-wings white; a thickening of whitish-ochreous hairs along lower margin of cell and base of 3, costal area above this and extending to apex of 7 whitish-ochreous.

Paumotus, Fakarava, February, in herbage; 1 ex. This specimen is largely denuded of scales, but there is no evidence of any markings, and the species is unmistakable by structure; it must be remembered, however, that the peculiar distortion of the neuration of hind-wings is doubtless sexual, and may probably not be reproduced in the female. It is so curious a type that it would have been a pity not to describe it.

Tinea monospila, n. sp.

♂. 6–7 mm. Head ochreous-white. Palpi blackish, tip white. Antennae, thorax dark grey. Fore-wings grey irrorated blackish; a small rather elongate ochreous-whitish spot on dorsum towards tornus: cilia grey with rows of blackish points. Hind-wings and cilia dark grey.

Society Is., Tahiti, March (*Miss Cheesman*); 1 ex. Probably allied to *chlorospora* from Fiji, and some of the small Australian species.

Trachycentra calamias, Meyr.

Marquesas, Nuka Hiva, January, amongst dead banana leaves; 1 ex. Also occurs in Tonga, Samoa, and Fiji; the larva is unknown, but it is very probable that the dead banana leaves (to which the colouring of the imago is adapted) are its natural food.

South American Species.

Sixty-seven species were obtained in recognisable condition, besides a certain number of others which were not in sufficiently good preservation to be determined or described. Of this number five genera and thirty-nine species are described as new.

Pterophoridae.

Adaina primulacea, n. sp.

♂. 13 mm. Head, thorax pale yellow, shoulders white. Palpi whitish. Fore-wings pale yellow, becoming white towards costa from base to ¾; a small indistinct grey dot

just before base of cleft: cilia yellow-whitish. Hind-wings yellow-whitish, third segment yellower; cilia yellow-whitish.

Panama, Taboga I., 500 feet, September, at light; 1 ex.

Tortricidae.

Capua illaqueata, Meyr.

Colombia, Gorgona I., 200 feet, October, at light; 1 ex.

Sparganothis rostrana, Walk.

Panama, Taboga I., 500 feet, September, at light; 1 ex.

Amorbia productana, Walk.

Colombia, Gorgona I., 200 feet, October, November, at light; 2 ex.

Eucosmidae.

Laspeyresia ancoloba, Meyr.

Panama, Taboga I., 500 feet, September, at light.

Gelechiadae.

Copticostola, n. g.

Head with appressed scales; ocelli posterior; tongue developed. Antennae $\frac{4}{5}$, scape moderate, without pecten. Labial palpi long, recurved, second joint thickened with appressed scales, terminal joint little more than half second, moderate, pointed. Maxillary palpi rudimentary. Posterior tibiae clothed with hairs above. Fore-wings 2 from $\frac{3}{4}$, 3–5 rather approximated, 6 to apex, 8 absent, 11 from middle. Hind-wings under 1, elongate-trapezoidal, termen sinuate, cilia nearly 2; 3 and 4 connate, 5 approximated, 6 and 7 stalked; with cubital pecten.

Belongs to group of *Battaristis*.

Copticostola acuminata, Wals.

Untomia acuminata, Wals., Biol. Centr. Am. Lep. Het., iv, 75, pl. ii, 31.

Colombia, Gorgona I., 200 feet, November, at light; 1 ex. Walsingham's example was from Mexico; the species differs from *Untomia* in palpi and neuration of fore-wings.

Onebala archigrapha, n. sp.

♂. 19 mm. Head, thorax lilac-grey. Palpi grey, anterior edge very finely white bordered blackish. Fore-wings elongate, somewhat dilated, termen nearly vertical, faintly sinuate beneath apex; bluish-grey; a slender brownish streak above middle from base to $\frac{1}{3}$, its posterior third pale ochreous; a very dark chocolate-brown semioval blotch finely edged whitish extending along dorsum from $\frac{1}{5}$ to $\frac{3}{5}$ and reaching more than half across wing, discal edge rather irregular; an oblique pale ochreous-greyish line followed by brownish suffusion from costa at $\frac{2}{5}$ to a group of three adjacent dark fuscous whitish-edged spots placed transversely on end of cell, uppermost dot-like, median largest, suboval, lowest

subtriangular; apical area dark fuscous, limited by two parallel fine cloudy irregular whitish-grey lines running from costa at $\frac{2}{3}$ to dorsum before tornus, second white on costa, a curved blue-leaden-metallic shade in this space from $\frac{5}{8}$ of costa to tornus, a fine grey-whitish sinuate line between this and termen: cilia glossy bluish-grey. Hind-wings dark fuscous, lighter anteriorly; cilia grey.

COLOMBIA, Gorgona I., 200 feet, July, at light; 1 ex. Also an example in my collection from R. Maroni, French Guiana. Allied to *symbolica* and *adaequata*.

Cymotricha turrita, Meyr.

COLOMBIA, Gorgona I., 200 feet, October, at light; 1 ex., worn.

Trichotaphe retracta, Meyr.

PANAMA, Taboga I., 1000 feet, September, at light; 1 ex.

Eupragia oxinopa, n. sp.

♂. 17 mm. Head white, crown centrally tinged ochreous. Palpi white, second joint fuscous except towards apex. Thorax white, tegulae fuscous. Fore-wings elongate, posteriorly dilated, costa nearly straight, apex obtuse, termen rounded, rather oblique; 7 and 9 stalked, 7 to apex, 8 absent, 12 hardly approximated to 11; white, veins marked fine fuscous lines; three short streaks of fuscous suffusion lying on these towards base, and three longer ones beyond cell; a short black dash representing first discal stigma; a series of small indistinct fuscous spots between veins near apex and termen; a marginal series of black marks round apical part of costa and termen: cilia whitish-ochreous. Hind-wings and cilia ochreous-whitish; a blackish dot on apical edge.

COLOMBIA, Gorgona I., 200 feet, November, at light; 1 ex. The differences in neuration from Walsingham's typical species are probably not generic, being similar in part to those occurring in the allied genus *Glyphidocera*, and the species being otherwise evidently related.

Glyphidocera lepidocyma, n. sp.

♂ 15 mm. Head pale ochreous. Palpi, thorax light ochreous thinly sprinkled dark fuscous. Antennal notch moderate. Abdomen smooth, whitish-ochreous. Fore-wings elongate, costa slightly arched, apex obtuse, termen obliquely rounded; 6 and 7 short-stalked; light ochreous, thinly speckled dark fuscous; stigmata dark fuscous, discal moderate, plical small, rather before first discal, an additional dot beneath and rather before second discal: cilia pale grey, becoming pale ochreous on costa. Hind-wings thinly scaled, grey; a suberect fringe of short pale grey hairscales along lower margin of cell; cilia pale grey.

COLOMBIA, Gorgona I., 200 feet, November, at light,; 1 ex.

Glyphidocera illiterata, n. sp.

♂♀. 11 mm. Head light fuscous. Palpi fuscous, apex of second joint pale. Antennal notch ♂ deep, strengthened by scale-tuft beneath. Thorax fuscous. Abdomen greyish, ♂ basal half strewn with loosely appressed long grey-whitish hairscales. Fore-wings elongate, costa gently arched, apex obtuse, termen rounded, somewhat oblique; 6 and 7 short-stalked; fuscous, darker-sprinkled: cilia grey. Hind-wings grey-whitish or whitish-grey; cilia whitish.

PANAMA, Balboa, Juné, at light; 3 ex.

Glyphidocera melithrepta, n. sp.

♂♀. 11–12 mm. Head, thorax dark purplish-fuscous, face pale ochreous. Palpi dark grey, apex of joints whitish, second joint ♂ light yellow-ochreous slightly tinged grey, ♀ light yellowish internally only. Antennal notch ♂ large, with strong scale-projection beneath. Abdomen dark grey (♂ missing). Fore-wings elongate, costa gently arched, apex obtuse, termen somewhat obliquely rounded; 6 and 7 short-stalked; dark purple-fuscous: cilia grey. Hind-wings rather dark grey; cilia grey, a darker subbasal shade.

COLOMBIA, Gorgona I., 200 feet, October, at light; 3 ex.

Glyphidocera orthotenes, n. sp.

♂. 13 mm. Head, thorax light ochreous, shoulders sprinkled grey. Palpi light ochreous irrorated dark grey. Antennal notch well-marked, scape long. Abdomen grey, strewn with long appressed whitish-ochreous hairscales, anal tuft whitish-ochreous. Fore-wings elongate, rather narrowed anteriorly, costa almost straight, faintly sinuate, apex obtuse, termen straight, rather oblique; 6 and 7 short-stalked; light yellow-ochreous, thinly speckled dark fuscous, anterior half of costa suffusedly irrorated dark fuscous; stigmata cloudy, fuscous, first discal rather large, second moderate, plical moderate, rather before first discal, an additional dot close beneath and before second discal; a fuscous marginal line on apex and upper part of termen: cilia grey, a dark grey median line. Hind-wings thinly scaled, grey; cilia light grey, a darker subbasal line.

COLOMBIA, Gorgona I., 200 feet, October, at light; 1 ex.

Glyphidocera eurrhipis, n. sp.

♂. 13–14 mm. Head, thorax whitish-ochreous. Palpi whitish-ochreous sprinkled dark fuscous except apex of joints. Antennal notch deep, strengthened by scale-tuft beneath. Abdomen whitish-ochreous, with long double dense pale yellow-ochreous expansible hairpencils from segments 5 and 6 projecting posteriorly over back. Fore-wings elongate, widest in middle, costa gently arched, apex obtuse, termen rounded, rather oblique; 6–9 closely approximated at base; pale ochreous-yellowish, thinly speckled dark fuscous; indistinct dark fuscous dots in disc near base and at $\frac{1}{4}$; stigmata moderate, dark fuscous, plical rather obliquely before first discal, an additional indistinct dot beneath and slightly before second discal; some fuscous irroration extending from costa at $\frac{3}{4}$ towards second discal, and some towards termen; two or three small dark fuscous marginal spots round apex: cilia whitish-yellow, somewhat sprinkled grey. Hind-wings pale grey, towards dorsum tinged whitish-yellowish; cilia ochreous-whitish, tinged grey round apex.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 2 ex.

Glyphidocera sagifera, n. sp.

♂. 14 mm. Head, thorax fuscous. Palpi fuscous, extreme tips of joints whitish. Antennal notch very slight. Abdomen fuscous, clothed above with loosely rough fuscous-whitish hairscales except last two segments, anal tuft light greyish-ochreous. Fore-wings elongate, costa slightly arched, apex obtuse, termen obliquely rounded; 6–9 closely approximated at base; fuscous, sprinkled dark fuscous; stigmata moderate, dark fuscous, plical indistinct, rather before first discal; two or three small obscure dark marginal spots round apex: cilia fuscous. Hind-wings rather dark grey, scales rather roughened towards base and dorsum; cilia light grey, a darker subbasal shade.

COLOMBIA, Gorgona I., 200 feet, July, at light; 1 ex.

Glyphidocera cerochra, n. sp.

♂. 14–16 mm. Head, thorax light ochreous. Palpi pale ochreous irregularly sprinkled fuscous. Antennal notch well developed. Fore-wings elongate, costa slightly arched, apex obtuse, termen rounded, rather oblique; veins separate; light yellow-ochreous, slightly speckled dark fuscous; stigmata cloudy, formed of dark fuscous irroration, plical obliquely before first discal; three or four similar dots on termen: cilia pale yellow-ochreous, a median line of fuscous speckling. Hind-wings pale ochreous-yellowish; cilia pale yellowish. Uncus very long, slender, down-curved, from its middle beneath with long strong triangular process with short hooked point.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 5 ex.

Glyphidocera ptychocryptis, n. sp.

♂. 16–17 mm. Head, palpi, thorax fuscous. Antennal notch deep. Fore-wings elongate, costa gently arched, apex obtuse, termen rounded, somewhat oblique; 6–9 separate; rather dark fuscous; stigmata cloudy, obscurely darker, plical somewhat before first discal: cilia fuscous. Hind-wings cell short, $\frac{1}{3}$ of wing; grey; a deep supramedian groove, suffused dark fuscous on its median third, a pale greyish area above this suffusion; cilia grey. Uncus nearly as in *cerochra*, but process rather more remote from apex.

COLOMBIA, Gorgona I., 200 feet, October, November, at light; 3 ex.

Glyphidocera capraria, n. sp.

♂. 17 mm. Head, thorax pale greyish-ochreous. (Palpi missing.) Antennal notch well-developed. Abdomen smooth, greyish, basal half light greyish-ochreous; uncus as in *ptychocryptis*, but process slender, not triangularly expanded. Fore-wings elongate, costa gently arched, apex rounded-obtuse, termen rounded, little oblique; 6–9 separate; light greyish-ochreous, thinly speckled dark fuscous; stigmata dark fuscous, first discal elongate, second moderate, plical minute, rather before first discal, an additional small dot beneath second discal; four small subquadrate dark fuscous marginal spots round apex and upper part of termen: cilia light greyish-ochreous. Hind-wings grey, paler and ochreous-tinged anteriorly, space on each side of subdorsal fold except towards termen clothed with loosely appressed or somewhat rough hairscales.

COLOMBIA, Gorgona I., July, beaten from herbage near sea-level; 1 ex.

Glyphidocera drosophaea, n. sp.

♂. 15 mm. Head, thorax light brownish-ochreous. Palpi pale greyish-ochreous sprinkled dark fuscous. Antennal notch shallow. Abdomen light greyish, clothed with dense rough hairscales throughout. Fore-wings elongate, costa slightly arched, apex obtuse, termen rounded, somewhat oblique; 6–9 separate; light brownish-ochreous, sprinkled dark fuscous; a cloudy dark fuscous dot in disc at $\frac{1}{4}$; stigmata dark fuscous, discal moderate, plical minute, somewhat before first discal; some apical grey suffusion: cilia light ochreous, sprinkled dark grey. Hind-wings grey, anterior $\frac{2}{3}$ with scales somewhat modified, with pale bases; cilia light grey, a darker subbasal shade.

COLOMBIA, Gorgona I., 200 feet, November, at light; 1 ex.

COSMOPTERYGIDAE.

Panclintis, n. g.

Head smooth, forehead forming a strong obtuse cone; ocelli posterior; tongue developed. Antennae over 1, ♂ serrulate, shortly ciliated, scape long, rather swollen, with

slight pecten. (Labial palpi missing, assumed as in *Pammeces*.) Maxillary palpi rudimentary. Posterior tibiae clothed with rough hairscales above and beneath. Fore-wings 2 from towards angle, 6 and 7 out of 8, 7 to costa, 11 from near before middle. Hind-wings $\frac{2}{3}$, lanceolate, cilia 3; 2–5 parallel, 6 and 7 stalked.

Allied to *Pammeces*.

Panclintis socia, n. sp.

♂. 13 mm. Head, thorax brown. Antennae dark grey, scape brown. Fore-wings elongate-lanceolate; brown, a few scattered blackish specks; dorsal area suffused lighter yellowish-brown; plical and second discal stigmata formed by small groups of black irroration: cilia brownish-ochreous, becoming greyish towards tornus. Hind-wings and cilia dark fuscous.

Colombia, Gorgona I., 200 feet, October, at light; 1 ex.

Blastobasidae.

Auximobasis obstricta, Meyr.

Panama, Taboga I., 200 feet, September, at light; 1 worn ♀ ex.

Oecophoridae.

Triclonella umbrigera, n. sp.

♂. 15 mm. Head, palpi, thorax whitish irrorated brown. Fore-wings elongate, apex obtuse-pointed, termen very obliquely rounded; rather dark brown; extreme base of wing and dorsal edge near base ochreous-whitish; an undefined cloud of dark fuscous suffusion resting on dorsum about $\frac{1}{3}$ and extending across fold; discal stigmata obscure, fuscous; some fuscous suffusion along costa from about $\frac{1}{4}$ to $\frac{2}{3}$, cut by an indistinct obscure oblique whitish strigula about middle, some blackish speckling towards costa beyond this: cilia grey, basal half mixed blackish round apex and upper part of termen. Hind-wings grey, suffused darker posteriorly; cilia grey.

Panama, Taboga I., 200 feet, September, at light; 1 ex.

Doliotechna bimarginata, n. sp.

♂. 10 mm. Head, thorax light grey, forehead whitish. Palpi white, second joint dark grey except apex. Antennae dark grey, ciliations nearly 3. Fore-wings rather elongate, costa gently arched, apex obtuse, termen obliquely rounded; glossy light grey; costal edge dark fuscous towards base; an orange costal line from $\frac{1}{4}$ to near apex, edged beneath by a fine white line from $\frac{1}{4}$ to $\frac{3}{4}$; second discal stigma cloudy, blackish, a small erect blackish mark from dorsum slightly beyond this; an obtusely angulated series of small blackish dots from costa at $\frac{3}{4}$ to termen below middle: cilia pale ochreous, on costa towards origin tinged orange. Hind-wings rather dark grey; cilia grey.

Colombia, Gorgona I., 200 feet, October, at light; 1 ex. Nearest *hyalophaea*.

Machimia sciocrates, n. sp.

♂. 20–22 mm. Head yellow, crown spotted crimson. Palpi yellow, second joint crimson except apex, terminal joint with two crimson bands. Antennae grey, base yellow marked crimson, ciliations 3. Thorax yellow irregularly reticulated crimson. Abdomen dark grey, beneath ochreous-whitish. Fore-wings moderate, dilated, costa gently arched,

apex rounded-obtuse, termen rounded, little oblique; yellow reticulated crimson; markings dark fuscous; a short mark from base of costa; a broad irregular fascia slightly before middle, terminating on costa in two diverging arms at $\frac{1}{3}$ and beyond middle, broadest on dorsum where it extends from $\frac{1}{4}$ to $\frac{2}{5}$, posterior edge with obtuse prominence below middle; some dark fuscous reticulation beyond this towards dorsum, sending an irregular stria upwards to near costa; a moderate marginal fascia round apex and termen, enclosing a marginal series of yellow crimson-ringed dots: cilia yellowish, on termen with basal half crimson spotted dark grey, on tornus wholly dark grey. Hind-wings dark grey, sometimes slightly reddish-tinged towards costa; cilia dark grey.

COLOMBIA, Gorgona I., 200 feet, July, October, November, at light; 3 ex. Allied to *corallina*; the colouring strongly suggests a *Hypercallia*.

Machimia caumatias, n. sp.

♂. 17 mm. Head, thorax brownish, face paler. Palpi second joint fuscous, tip whitish, terminal joint whitish sprinkled fuscous except apex. Antennal ciliations fasciculated, 2. Fore-wings rather elongate, costa gently arched, apex rounded, termen rather obliquely rounded; brownish, costa and termen narrowly suffused fuscous; dorsal area suffused fuscous on basal fourth, darkest on edge, sending an oblique fascia of suffusion to costa at $\frac{2}{5}$; stigmata moderate, blackish, first discal on this fascia, plical obliquely beyond first discal; an indistinct fuscous obtusely angulated shade crossing wing just beyond second discal; a series of irregular blackish dots from beneath costa at $\frac{2}{3}$ parallel to margin, rather acutely angulated opposite apex and running to tornus: cilia light fuscous, base light brownish. Hind-wings grey; cilia light grey, base pale ochreous.

COLOMBIA, Gorgona I., 200 feet, October, at light; 1 ex.

Cryptolechia praevecta, n. sp.

♂. 13 mm. Head, thorax brownish, face whitish-ochreous. Palpi second joint fuscous (terminal broken). Fore-wings elongate, posteriorly dilated, costa anteriorly straight, posteriorly gently arched, apex obtuse-pointed, termen nearly straight, rather oblique; brownish, towards costa and dorsum posteriorly streaked dark fuscous between veins; stigmata rather cloudy, dark fuscous, first discal moderate, second large, plical minute, rather beyond first discal; an acutely angulated transverse series of ochreous-whitish marks from beneath costa at $\frac{2}{3}$ to near dorsum at $\frac{3}{4}$, its angle reaching to near termen beneath apex, and a praemarginal series of similar marks preceding dark fuscous marginal dots round apical part of costa and termen: cilia light brownish-ochreous. Hind-wings rather dark grey; cilia grey.

COLOMBIA, Gorgona I., 200 feet, November, at light; 1 ex.

Cryptolechia melanophthalma, n. sp.

♂♀. 16–18 mm. Head, thorax light fuscous. Palpi fuscous, anterior edge blackish edged on each side whitish. Fore-wings suboblong, somewhat narrowed anteriorly, apex rounded-obtuse, termen rounded, slightly oblique; light greyish-ochreous, transversely irregularly striated rather dark fuscous; a large round blackish-fuscous spot (second discal stigma) on end of cell; four or five minute dark fuscous terminal dots: cilia pale greyish. Hind-wings grey; cilia light grey.

COLOMBIA, Gorgona I., 200 feet, October, November, at light; 2 ex.

XYLORYCTIDAE.

Durrantia arcanella, Busck.

PANAMA, Taboga I., 1000 feet, September, at light; 1 ex.

Thyrsomnestis, n. g.

Head with broad appressed scales; ocelli posterior; tongue developed. Antennae $\frac{4}{5}$, scape moderate. Labial palpi very long, recurved, second joint with scales triangularly expanded towards apex above, terminal joint as long as second, slender, acute. Maxillary palpi very short, filiform, appressed to tongue. Posterior tibiae smooth-scaled. Fore-wings 2 from angle, 6 to apparent apex (indefinite), 8 absent, 11 from middle. Hind-wings 1, trapezoidal, termen slightly sinuate, cilia $\frac{3}{4}$; 3 and 4 connate, 5 approximated, 6 and 7 approximated at base.

Probably allied to *Eumiturga*, distinguished by palpi.

Thyrsomnestis ceramoxantha, n. sp.

♀. 10 mm. Head mixed pale grey-yellowish and reddish-grey. Palpi second joint fuscous, tip pale yellowish, terminal joint blackish-grey with fine median ring and tip white. Antennae whitish ringed black. Thorax greyish-ochreous somewhat marked yellow. Fore-wings elongate, costa gently arched, apex rounded, termen obliquely rounded; greyish-crimson, costa dark grey except towards apex; markings ochreous-yellow; irregular oblique streaks from costa at $\frac{1}{4}$ and beyond middle reaching fold; irregular direct streaks from dorsum at $\frac{1}{4}$ and middle reaching fold; an irregular direct streak crossing wing at about $\frac{2}{3}$; a marginal series of partially confluent dots round costa and termen beyond this: cilia light reddish-grey, outer half whitish. Hind-wings dark grey; cilia grey.

COLOMBIA, Gorgona I., 200 feet, November, at light; 1 ex. The specimen is defective, but the species is easily recognisable.

Antaeotricha ithytona, n. sp.

♂♀. 15–16 mm. Head, thorax light greyish, face and forehead whitish. Palpi white, basal $\frac{2}{3}$ of second joint greyish, indistinct subapical rings of second and terminal joints and base of terminal joint dark grey. Fore-wings elongate, nearly parallel-sided, slightly expanded before middle, apex rounded; 2 and 3 stalked, 8 absent, 7 and 9 approximated at base; white; a short suffused dark fuscous streak along base of dorsum; a straight very oblique irregularly interrupted suffused fuscous line from just beneath costa at $\frac{1}{4}$ to a suffused triangular or subquadrate dark grey blotch on dorsum about $\frac{2}{3}$, and a similar line from costa beyond middle to a triangular praetornal blotch, plical and second discal stigmata appearing as small suffused dark fuscous spots on these respectively; a straight oblique dark fuscous line from costa about $\frac{5}{6}$ to above posterior angle of second blotch; three dark fuscous marginal dots round apex: cilia white. Hind-wings 3 and 4 coincident; light grey; in ♂ an ochreous-whitish expansible hairpencil from base lying beneath costa to $\frac{2}{3}$; cilia whitish, a light grey subbasal shade.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 7 ex. Allied to *ovatella* and *tractrix*.

Antaeotricha ovatella, Walk.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 12 ex. This species has vein 8 of fore-wings absent, 3 and 4 of hind-wings stalked.

Stenoma byssina, Zell.

Panama, Taboga I., 500–1000 feet, September, at light; 2 ex.

Stenoma chloroplaca, Meyr.

Panama, Taboga I., 1000 feet, September, at light; 1 ex.

Stenoma symphonica, Meyr.

Panama, Balboa, June, at light; 1 ex.

Stenoma figularis, Meyr.

Colombia, Gorgona I., 200 feet, October, at light; 2 ex.

Stenoma bicensa, Meyr.

Panama, Corozal, near Balboa, June, at light; 1 ex.

Stenoma leucana, Sepp.

Panama, I. del Rey, June; 2 ex.

Stenoma sustentata, Meyr.

Colombia, Gorgona I., 200 feet, July, October, at light; 4 ex., smaller (19–20 mm.) and less heavily marked than the original specimen (taken at 4000 feet), but otherwise not distinguishable.

Stenoma ochricollis, Zell.

Colombia, Gorgona I., 200 feet, October; Panama, Taboga I., 1000 feet, September; at light, 2 ex.

Stenoma curiata, n. sp.

♀. 22 mm. Head, thorax light reddish-brown, face whitish-tinged. Palpi light reddish-brown, terminal joint tinged whitish. Fore-wings suboblong, slightly dilated, costa gently arched, apex rounded, termen rounded, vertical; 2–4 closely approximated, 7 to apex (indefinite); light brown, scattered dark fuscous scales, costa rosy; two fuscous lines, suffusedly expanded on costa, first from middle of costa to $\frac{1}{4}$ of dorsum, widely interrupted beneath costa, second from $\frac{2}{3}$ of costa to dorsum before tornus, excurved in disc and slightly sinuate towards costa; in disc at $\frac{3}{5}$ a transverse-oval blotch of ground-colour outlined fuscous; a fine fuscous terminal line: cilia pale grey, tinged rosy towards base. Hind-wings light grey, towards apex tinged ochreous; cilia ochreous-whitish.

Panama, Taboga I., 200–1000 feet, September, at light; 3 ex. Allied to *satyropa*, but fore-wings much less dilated.

Stenoma aphrogramma, n. sp.

♀. 27–30 mm. Head greyish-ochreous, face whitish. Palpi ochreous-grey mixed white, anteriorly tinged yellowish towards base. Thorax pale greyish-ochreous. Abdomen light ochreous-yellowish, deeper towards apex. Fore-wings moderately broad, costa

strongly and evenly arched, apex rounded, termen rounded, little oblique; 2–5 approximated, 7 to costa (indefinite); light greyish-ochreous or ochreous-grey, extreme costal edge tinged whitish; a slender streak of white suffusion from base of dorsum running parallel to costa to middle; some slight whitish suffusion leading from apex of this to grey dot-like second discal stigma, laterally edged whitish; a broader streak of whitish suffusion beneath and parallel to posterior $\frac{2}{3}$ of costa; an almost terminal series of dots of white suffusion: cilia pale yellow-ochreous. Hind-wings ochreous-whitish; cilia pale ochreous-yellowish.

Panama, Taboga I., 200-1000 feet, September, at light; 3 ex. Near *chlorina*, Kearf., but distinguished from this and allied species by whitish hind-wings.

Stenoma exarata, Zell.

Colombia, Gorgona I., 200 feet, November, at light; 1 ex.

Stenoma syndicastis, n. sp.

♂. 23 mm. Head, thorax white. Palpi white, second joint dark fuscous except extreme tip. Antennae grey, ciliations 1½. Abdomen light ochreous-yellowish, base and apex white. Fore-wings elongate, slightly dilated, costa gently arched, apex rounded, termen obliquely rounded; 2 and 3 stalked, 7 absent (coincident with 8); snow-white: cilia white. Hind-wings 6 and 7 rather short-stalked; white; cilia white. Fore-wings beneath whitish, costal $\frac{2}{3}$ light ochreous-yellow becoming deeper towards costa, lower margin of cell and veins 3–5 also tinged yellowish. Hind-wings beneath white, tinged pale yellowish towards costa.

Colombia, Gorgona I., 200 feet, July, at light; 1 ex.

Stenoma butyrota, n. sp.

♂. 29 mm. Head, thorax, abdomen white. Palpi white, second joint dark fuscous except apex. Antennae dark grey, ciliations 1. Fore-wings considerably dilated, costa anteriorly gently, posteriorly very strongly arched, apex rounded, termen obliquely rounded; 2 from near angle, 3–5 nearly approximated; snow-white: cilia white. Hind-wings 6 and 7 very short-stalked; ochreous-white, yellowish-tinged on dorsum and towards apex; cilia white. Fore-wings beneath light ochreous-yellow, deeper towards costa, along dorsum whitish, a moderate suffused grey terminal fascia. Hind-wings beneath whitish, becoming light ochreous-yellow towards costa and apex, white towards dorsum.

Colombia, Gorgona I., 200 feet, October, at light; 1 ex.

Ptilogenes lichenias, Meyr.

Colombia, Gorgona I., 200 feet, July, October, November, at light; 3 ex.

Ptilogenes apoclina, n. sp.

♂. 18–19 mm. Head white, crown mixed fuscous. Palpi white, second joint with thick dark fuscous lateral streak on basal half and fine subapical ring of irroration, terminal joint with base and subapical ring dark fuscous. Antennal ciliations 1½. Thorax whitish sprinkled light grey, anterior margin suffused light grey. Fore-wings moderate, hardly dilated, costa gently arched, apex rounded, termen rounded, somewhat oblique; whitish slightly speckled light fuscous; three irregular oblique lines formed of disconnected blackish marks more or less suffused brownish, running from small spots on costa at ¼, middle, and

$\frac{3}{4}$, first finely connected and dentate in disc, rather curved, second strong on costal $\frac{2}{5}$, little marked on lower half but sending from middle a streak of brown and black suffusion to termen below middle, third running to near tornus, excurved in disc, sinuate towards dorsum; a submarginal series of small brownish spots round apex and upper part of termen; a terminal series of brownish marks: cilia whitish, base barred brownish. Hind-wings rather dark grey; cilia light grey, a darker subbasal line.

COLOMBIA, Gorgona I., 200 feet, October, November, at light; 5 ex. Near *lichenias*.

Ptilogenes ungulifera, n. sp.

♂. 21–23 mm. Head whitish-ochreous, face whitish. Palpi light fuscous, second joint mixed dark fuscous on basal half, tip whitish, terminal joint with apex and submedian band obscurely whitish. Antennal ciliations $1\frac{1}{2}$. Thorax pale brownish mixed white anteriorly, anterior margin rather dark brown. Fore-wings moderate, rather dilated, costa anteriorly slightly, posteriorly strongly arched, apex rounded, termen rounded, rather oblique; light brownish, costal $\frac{2}{3}$ mixed whitish and grey; some grey suffusion on costa towards base; a minute black dot on fold beneath middle; a transverse blackish mark on end of cell, separated by a spot of white suffusion from a rounded-ovate brown apical blotch, partly marked blackish on anterior edge, with two oblique blackish streaks towards costa, and enclosing an inner apical subquadrate brown blotch cut off by a strong semicircular black streak and with its upper anterior angle pale ochreous; a blackish marginal line round apex and dots above and below this, preceded by slight whitish tinge: cilia pale greyish, a dark grey subbasal line. Hind-wings rather dark grey; cilia light grey, a dark grey subbasal line.

COLOMBIA, Gorgona I., 200 feet, October, November, at light; 2 ex. Next *ommatopa*.

Ptilogenes disticha, Meyr.

COLOMBIA, Gorgona I., 200 feet, July, October, November, at light; 6 ex.

Ptilogenes diorista, n. sp.

♂. 12 mm. Head white. Palpi white, basal $\frac{2}{3}$ of second joint dark fuscous. Antennal ciliations 3. Thorax dark fuscous. Fore-wings rather elongate, posteriorly dilated, costa moderately arched, apex rounded, termen obliquely rounded; white, partially slightly greyish-tinged; a dark fuscous basal patch occupying nearly $\frac{1}{5}$ of wing, edge suffused, nearly direct; some irregular grey suffusion along dorsum, broader beyond middle, and some on costa beyond middle; a small blackish spot in disc at $\frac{1}{3}$, and a larger one beyond $\frac{2}{3}$; a suffused grey irregular curved fascia from about $\frac{2}{3}$ of costa to tornus, including a series of blackish marks, and leaving a narrow white terminal fascia, in this six small hemispherical dark fuscous marginal spots round apical part of costa and termen: cilia white, two interrupted greyish lines. Hind-wings light grey, a small dark grey apical blotch containing two or three white marks; cilia whitish-grey, a darker grey subbasal shade.

COLOMBIA, Gorgona I., 200 feet, July, November, at light; 2 ex.

Ptilogenes anamochla, n. sp.

♂. 11 mm. Head white. Palpi white, basal $\frac{2}{3}$ of second joint irrorated dark fuscous, a slight subapical ring of second joint and base of terminal fuscous. Antennal ciliations 3. Thorax white, some minute fuscous speckling. Fore-wings rather elongate, slightly dilated, apex obtuse, termen rounded, rather oblique; white, minutely speckled fuscous;

suffused fuscous marks on costa before ⅓ and at middle; a transverse rectangular brown blotch from dorsum somewhat beyond middle, reaching more than half across wing, crossed by a thick black bar beneath its apex, below this margined on each side and on dorsum with grey sprinkled black; second discal stigma small, black, near beyond upper posterior angle of this; some transverse fuscous suffusion following this, confluent beneath with a rather broad terminal fascia of fuscous suffusion, darkest towards apex: cilia grey with three blackish lines, towards tornus tinged whitish. Hind-wings except a rather narrow light grey terminal fascia hyaline thinly strewn with fine grey hairscales with black points; cilia grey-whitish, a light grey subbasal shade.

Colombia, Gorgona I., 200 feet, November, at light; 1 ex. Allied to *dryosphaera*.

Ptilogenes leptobelisca, n. sp.

♂. 20–22 mm. Head, thorax fuscous mixed white. Palpi white, second joint suffused fuscous except apex, terminal joint with base and subapical band dark fuscous, sprinkled fuscous anteriorly between these. Antennal ciliations 1½. Fore-wings moderate, rather dilated, costa hardly arched, apex rounded-obtuse, termen slightly rounded, somewhat oblique; light brownish suffusedly mixed white; a fine black irregular median line from near base to beyond middle; an oblique dark brown shade mixed black from base of costa to this; a series of suffused darker brown elongate spots acutely angulated in middle from costa at ¼ to dorsum at ⅜; a similar series from middle of costa to dorsum at ⅝, acutely angulated but widely interrupted on angle; a suffused darker brown elongate spot on costa at ⅞, whence a curved series of undefined marks of blackish irroration, interrupted above middle, proceeds to dorsum before tornus, on lower portion confluent with preceding; a submarginal series of elongate dark brown spots more or less expressed: cilia brownish, basal half spotted dark brown, these spots towards tornus separated with white. Hind-wings rather dark grey; cilia grey, a darker subbasal line.

Colombia, Gorgona I., 200 feet, July, October, November, at light; 13 ex. Allied to *complexa*, but not very closely.

Ptilogenes illita, Meyr.

Colombia, Gorgona I., 200 feet, July, October, November, at light; 25 ex.

Ptilogenes oxyplaca, n. sp.

♀. 18 mm. Head white. Palpi white, second joint tinged grey except tip, base and subapical ring of terminal joint grey. Thorax fuscous tinged whitish on dorsum anteriorly, tegulae whitish except towards base. Fore-wings hardly dilated, costa gently arched, apex rounded-obtuse, termen rather obliquely rounded; rather dark fuscous; a snow-white semioval blotch pointed anteriorly extending along costa from near base to ⅓ and reaching almost half across wing; an undefined terminal fascia of white irroration and suffusion: cilia white, on costa greyish from blotch to near apex. Hind-wings grey, darker towards apex; cilia pale grey, a darker subbasal shade.

Colombia, Gorgona I., 200 feet, July, at light; 1 ex. Next *argocymba*.

Glyphipterygidae.

Brenthia acmogramma, Meyr.

Panama, Coiba I., September; 1 ex., worn.

HYPONOMEUTIDAE.

Atteva punctella, Cram.

PANAMA, Coiba I., 10 ex. bred September from larvae feeding gregariously on a low-growing plant in a conspicuous white web covering upper part of plant; larva varying from light brown to nearly black; faint white subdorsal and well-marked white supraspiracular lines, above latter some dark brown mottling, head black spotted white; pupation in larval web (*Miss Longfield*).

Ethmia xantholitha, n. sp.

♂♀. 18–22 mm. Head white, lower part of face dark grey. Palpi white, second joint more or less largely suffused dark grey. Thorax white, blackish bars behind collar and before posterior extremity. Abdomen dark grey, anal segment and ventral surface yellow-ochreous. Fore-wings white; costal edge greyish from base to $\frac{2}{3}$; four somewhat irregular black transverse streaks, nearly or quite connected by black bars just beneath the grey costa, first near base, fourth at $\frac{2}{3}$, angulated inwards in disc, third and fourth enclosing a quadrate orange blotch on lower half edged above and on dorsum by black bars interrupted in middle; beyond fourth two other slenderer rather irregular black transverse lines, first not reaching dorsum, connected with preceding by two bars in disc and with second by one bar, second sinuate, more or less interrupted in middle, apical area beyond it orange: cilia light greyish-ochreous, base white. Hind-wings grey, darker towards termen; cilia white, base grey.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 53 ex. Near *cypraeella*.

Ethmia hammella, Busck.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 41 ex.

Ethmia baliostola, Wals.

COLOMBIA, Gorgona I., 200 feet, July, October, November, at light; 40 ex.

PLUTELLIDAE.

Acrolepia oxyglypta, n. sp.

♀. 9 mm. Head, thorax dark fuscous, face fuscous-whitish. (Palpi missing.) Fore-wings rather elongate, posteriorly dilated, costa gently arched, termen rather oblique; dark fuscous, slightly purplish-tinged; an acute triangular ochreous-white blotch from dorsum before middle, reaching $\frac{2}{3}$ across wing; five oblique white strigulae from posterior half of costa, first reaching $\frac{1}{3}$ across wing, others gradually diminishing; a short fine white erect strigula from dorsum before tornus; a minute white mark on termen beneath apex: cilia dark fuscous (imperfect). Hind-wings dark grey; cilia grey (imperfect).

PANAMA, Taboga I., 500 feet, September, at light; 1 ex. The resemblance to *Glyphipteryx* is interesting.

TINEIDAE.

Exoncotis resona, n. sp.

♂. 14–17 mm., ♀. 20–25 mm. Head light greyish-ochreous. Palpi pale greyish-ochreous, second joint with two dark fuscous bands or wholly suffused dark fuscous except

apex, terminal joint with two dark fuscous rings. Thorax fuscous, posterior edge pale greyish-ochreous. Fore-wings elongate, costa gently arched, apex obtuse, termen obliquely rounded; pale ochreous, partially suffused or strigulated brown, costal area from base to beyond middle with irregular suffused dark brown dots or strigulae; a small elongate dark brown spot on costa beyond middle, a smaller one beyond this, then a dot and a small spot before apex; a triangular dark brown spot on end of cell: cilia pale ochreous, irregularly barred dark brown suffusion on lower part of termen and above apex. Hind-wings rather dark grey; cilia grey.

COLOMBIA, Gorgona I., 200 feet, July, October, November, at light; 11 ex.

Episyrta, n. g.

Head with dense loosely appressed hairs; ocelli posterior; tongue absent. Antennae $\frac{2}{3}$, ♂ moderately fasciculate-ciliated, scape moderate, without pecten. Labial palpi moderate, curved, ascending, thickened with appressed scales, second joint rough-scaled anteriorly, terminal joint shorter than second, obtuse. Maxillary palpi obsolete. Thorax with posterior crest. Posterior tibiae rough-scaled above and beneath. Fore-wings with rough scales on surface; 2 from near angle, 7 to costa, 8 absent, 9 approximated, 11 from before middle. Hind-wings 1, elongate-ovate, cilia $\frac{2}{3}$; 2–7 nearly parallel, 5 and 6 somewhat approximated.

Possibly an early form of the *Hapsifera* group.

Episyrta coniomicta, n. sp.

♂. 17–18 mm. Head, thorax light brownish. Palpi brown, second joint sprinkled dark fuscous. Antennal ciliations somewhat over 1. Fore-wings elongate, slightly dilated, costa gently arched, apex rounded-obtuse, termen rather obliquely rounded; pale brownish-ochreous, irregularly and suffusedly irrorated brown, with scattered dots or groups of grey-whitish black-tipped raised scales, especially towards dorsum and termen, costal and dorsal areas more or less wholly suffused brown, dorsal area projecting triangularly on end of cell: cilia pale ochreous mixed brown, with obscure greyish bars sprinkled black. Hind-wings and cilia grey.

COLOMBIA, Gorgona I., 200 feet, July, November, at light; 3 ex.

Xerocausta, n. g.

Head shortly rough-scaled (somewhat injured); ocelli posterior; tongue absent. Antennae $\frac{1}{2}$, ♂ subdentate, shortly ciliated, scape moderate, without pecten. Labial palpi rather long, recurved, second joint thickened with short rough projecting scales beneath, without bristles, terminal joint shorter than second, rough anteriorly towards base, tolerably pointed. Maxillary palpi short, filiform, pointed, porrected. Fore-wings 2 from near angle, 7 to apex, 8–10 from near end of cell, 11 from before middle, accessory cell developed. Hind-wings 1, elongate-ovate, cilia $\frac{2}{3}$; 2–7 nearly parallel.

Xerocausta ceramochra, n. sp.

♂. 15 mm. Head, thorax ferruginous-ochreous, face pale ochreous. Palpi pale ferruginous-ochreous. Fore-wings elongate, slightly dilated, costa slightly arched, apex obtuse, termen obliquely rounded; ochreous irregularly mixed and suffused ferruginous; costa suffused dark ferruginous-brown from base to beyond middle; a rounded-subtriangular patch of ferruginous-brown suffusion occupying posterior half of dorsum and tornal area and reaching $\frac{2}{3}$ across wing, edged anteriorly except near dorsum by a whitish line;

some slight dark fuscous sprinkling towards apex: cilia ferruginous-ochreous. Hind-wings blackish-grey; cilia grey.

COLOMBIA, Gorgona I., 200 feet, October, at light; 1 ex.

Acrolophus synapta, Durr.

PANAMA, Corozal, near Balboa, June, at light; 3 ex.

Acrolophus pusilla, Zell. (?).

COLOMBIA, Gorgona I., 100 feet, October, at light; 1 ♂, possibly this species, agreeing apparently in form, structure, and genitalia, but larger (20 mm.), and with dark grey hind-wings.

Acrolophus tholomicta, n. sp.

♂. 13–15 mm. Head whitish-ochreous, sides of crown mixed dark brown. Palpi extremely long, recurved, reaching to middle of thorax, rough-scaled, pale ochreous mixed dark brown. Antennae flatly subdentate, moderately ciliated. Thorax whitish-ochreous mixed dark brown. Uncus abruptly bent down at right angles, moderate, apparently double but appressed throughout; valvae elongate, moderate, lower margin rather deeply sinuate in middle, apex rounded. Fore-wings elongate, rather dilated, costa moderately arched, apex rounded, termen rounded, somewhat oblique; 8 and 9 stalked; whitish-ochreous, irregularly irrorated brownish; 8–10 irregular dark fuscous small spots or dots along costa; a subtriangular patch of fuscous suffusion extending on costa from before $\frac{1}{3}$ to beyond $\frac{2}{3}$ and reaching to about fold, sometimes a dark fuscous spot in its apex, a whitish dot in an excavation of its posterior margin more or less apparent; some fuscous suffusion towards termen: cilia grey-whitish irrorated fuscous and dark fuscous (injured). Hind-wings rather dark grey; cilia light greyish, a darker subbasal shade.

COLOMBIA, Gorgona I., 200 feet, July, October, at light; 4 ex.

Acrolophus capax, n. sp.

♂. 35 mm. Head, palpi, thorax dark brown; palpi (second and terminal joints missing, but) of extremely long recurved type. Antennae with strong appressed flat dentations, very shortly ciliated. Fore-wings rather elongate (more so than in allied species), dilated, apex rounded, termen somewhat obliquely rounded; veins separate; dark brown, partially tinged ferruginous, scattered cloudy dark fuscous strigulae; two undefined darker fuscous spots beneath fold at $\frac{1}{4}$ and middle of wing, connected by a ferruginous-brown space, and a similar dark fuscous spot on end of cell (cilia injured). Hind-wings dark fuscous; cilia fuscous. Uncus rectangularly bent down (angle subacute-prominent), double, well separated and nearly parallel, gradually narrowed to point, beneath with long narrow process at base; valvae moderately broad, apex gradually rounded, lower edge slightly triangular-prominent in middle.

COLOMBIA, Gorgona I., 200 feet, July, at light; 1 ex. Not in good condition, but differing from similar species by the genitalia.

VARIETIES OF BRITISH LEPIDOPTERA IN THE HOPE DEPARTMENT, OXFORD UNIVERSITY MUSEUM

By the late Francis Cardew Woodforde, B.A., F.E.S., Exeter College, Oxford, in collaboration with E. B. Ford, M.A., B.Sc., F.E.S., Wadham College, Oxford, and L. B. Prout, F.E.S., and an Introductory Note by Prof. E. B. Poulton, D.Sc., F.R.S.

[Read October 3rd, 1928.]

Plate XXII.

Introductory Note.

It is much to be regretted that this paper did not appear in its author's lifetime. The pressure of other work prevented me until quite recently from giving the time necessary for the correspondence and verification of data which the author's long illness prevented him from undertaking. Certain short sentences added by me are placed between brackets; others, and a few slight changes here and there, it did not seem necessary to indicate. Mr. Ford's interesting section on *Heodes phlaeas* is signed by his initials, and Mr. Prout's valuable notes on the Geometridae are quoted from his manuscript under the respective species.

The plate, with the exception of figures 4, 8, and 12, was drawn by Miss Eleanor Stoll-Bailey, and I desire to thank her for all the care and skill she devoted to the work. The beautiful figures of *dispar* (8) and *geomella*, the new aberration of *X. fluctuata* (4), were most kindly drawn by Miss Balfour, and that of *Cyaniris argiolus* (12) by the late Miss M. L. Woodforde.

The varieties here recorded and figured have been selected from the Hope-Westwood Collection and the following collections now incorporated in it—R. J. Champion, W. M. Geldart, Raphael Meldola, W. G. Pogson-Smith, Arthur Sidgwick, F. M. Spilsbury; also from the historic J. C. Dale Collection which, by the terms of the bequest, is kept separate.

The most interesting specimens in this last collection have been described by Commander J. J. Walker, Hon. M.A., F.L.S., in a series of papers in the *Entomologist's Monthly Magazine* (vol. xliii, 2nd Ser. xviii, 1907, pp. 93, 130, 154) and in both Dale and Hope-Westwood collections by the author, in *The Entomologist* (vol. liii, 1920, pp. 152, 173, 199, 257; liv, 1921, pp. 8, 90, 140, 161, 287; lv, 1922, p. 12; lviii, 1925, p. 177). In referring to any of these papers and others in the same journals the contractions "*E.M.M.*" and "*Entom.*" will be employed with the year and page, but generally omitting the volume.

The author, after resigning the headmastership of the Market Drayton Grammar School in 1909, began in the following year to devote his time and great experience to the collections of British Lepidoptera in his University—a labour of love continued until his last illness, and only interrupted during the war, when he went back to his old profession in order to release a younger man for service. And even to the last his wandering thoughts were continually with his work and of his intention to visit the museum as soon as he recovered. His great knowledge and kindly humour will long be missed in Oxford. We may find comfort in the thought that the years spent in helping others to study the insects he loved so well, were years which brought happiness to himself.—E. B. P.

Gonepteryx rhamni, L. (Fig. 14.)

This very fine gynandromorph was taken in Caversham Warren, near Reading, about 1873, by Mr. F. W. Andrewes (now Sir Frederick Andrewes, D.M., F.R.S.), and given by him to Prof. Poulton, who presented it to the Hope Collection. The male colour predominates except in the left fore-wing, where all but a narrow stripe along the costa is of female coloration. A fairly broad stripe along the costa of the right hind-wing is also of female coloration, making a curious distribution of male and female colouring. On the underside there are streaks of female coloration on *both* fore-wings, but both hind-wings are entirely of male colour.

G. rhamni is not a species much given to variation, but the undersides of two or three specimens of both sexes in the Hope Collection are of a buff colour instead of the usual greenish yellow. (*Entom.*, vol. liii, 1920, p. 156.)

Colias hyale, L., ♂. (Fig. 19.)

This remarkable male specimen from the Spilsbury Collection is without data, which were unfortunately often omitted by collectors prior to 1870. The usual amount of black on the fore-wing is very greatly increased, extending inwards to the discal spot and downwards to the anal angle, while the amount of dark pigment on the margin of the hind-wing is much reduced.

The chief variation in this species seems to be confined to the amount of black in the apical section of the fore-wing and on margin of the hind-wing, and in the amount of yellow or white interspersed in the black. (*Ibid.*, p. 156.)

Aglais urticae, L., ♀. (Fig. 18.)

This specimen of ab. *ichnusoides*, Selys, was taken, probably August 1886, in the garden at Birr Castle, Parsonstown, Ireland, by the Hon. G. L. Parsons, M.A., Balliol College. In this form the black spots on the costa of the fore-wing partially or completely coalesce, thus diminishing or obliterating the pale costal blotches; the black blotch on the inner margin is increased in size, while the red of the central portion is much diminished, as are the two black spots in the red area of the fore-wing so constant in all forms (though varying in size) except the Corsican form *ichnusa*.

The whole surface of the hind-wings becomes a uniform dark brown colour.

Two similar examples in the collection are less heavily marked with black in the fore-wing, while the submarginal blue spots of the hind-wing, evanescent in the above, are well developed. One, with this latter feature especially strong and the outer marginal area of the fore-wing pale, is labelled "1876 : St. David's, S. Wales." The other was taken by a schoolboy, 30 July, 1918, at Ashley Heath, N. Staffordshire.

Other variations of *urticae* exist in the Hope Collection. In two specimens, taken by Mr. H. E. F. Onions on two successive days (August 4 and 5, 1918), in a garden at Market Drayton, the ground-colour instead of being red is very pale brown, almost ochreous, and this colour extends between the black blotches to the costa, but the blotch near the apex of the wing remains white. In a still more extreme variation without data in the Spilsbury Collection all the red is replaced by a cream-colour.

For an earlier record of all these varieties of *urticae*, see *ibid.*, p. 173.

Brenthis euphrosyne, L., ♂♂. (Figs. 15, 16.)

The specimen represented in Fig. 15 was taken near Oxford in June 1895 by the late Prof. W. M. Geldart, and that represented in Fig. 16 in Tubney Wood, Berks, 29 May, 1916, by the Rev. C. F. Thornewill. (*Ibid.*, p. 175.)

Aberration in the genus *Brenthis* is, as a rule, uncommon, and the usual tendency where it occurs is to an increase of the amount of black colouring in the wings and to an elongation of the black spots into rays. But an opposite tendency sometimes shows itself, when (as in Fig. 15) the whole of the reddish pigment is replaced by cream, or (as on the underside in Fig. 16) the whole ground-colour is palish ochreous and the usual reddish markings are wanting from the hind-wings.

Brenthis selene, Schiff., ♂. (Fig. 17.)

The tendency to an increase in the black pigment is well shown in this specimen, which was taken by the Rev. C. F. Thornewill at Crowthorne, Berks, 11 June, 1913. The submarginal black spots of the fore-wings are greatly enlarged and run into each other, forming an irregular black band. The basal portion of the hind-wings is also entirely black. (*Ibid.*, p. 175.)

Chrysophanus dispar, Haw., ♀. (Fig. 8.)

C. dispar is a very constant species, and aberrations are extremely rare, but this remarkable female in the Dale Collection is an exception. The whole outer portion of the fore-wings is black and the row of submarginal spots on this dark area only faintly indicated. The hind-wings and the underside are normal.

This specimen, " the gem of the whole collection " of twenty-six *dispar* in the Dale Collection, was described by Commander J. J. Walker, Hon. M.A., F.L.S., in *Entom. Monthly Mag.*, xliii (N.S. xviii), 1907, p. 131. The only label records " From Simmonds."

Heodes phlaeas, L., ♂♂. (Figs. 7, 13.)

Fig. 7 represents a specimen captured, 5 August, 1918, in the Burnt Woods near Market Drayton in North Staffordshire, and presented to the museum by Mr. H. E. F. Onions. Its remarkable appearance is due to the replacement of the copper ground-colour of the fore-wings, and the band within the outer margin of the hind-wings, by an unusual yellowish shade. Variations of a somewhat similar character are, of course, well known, in which the ground-colour may become a yellowish-white or cream colour (ab. *schmidtii*, Gerh.) or a pure white (ab. *alba*, Tutt). I cannot find, however, that this specimen conforms exactly to any named aberration, though it is probably to be referred to ab. *cuprinus*, Peyer, the original description of which is as follows :—

ab. *cuprinus*, Peyer.—" Cat. des Lép. d'Alsace," 1st ed., p. 8 (1871); 2nd ed., p. 23 (1880)—" Pallide lutea. Pâturages les plus élevés des Vosges—Hohneck, Rotabac, etc., Basses Rhin—vallée d'Andlau."

The validity of this aberration is sometimes questioned owing to the vagueness of the description. Thus Tutt remarks : " Whether this is a special mountain race or not is doubtful. It may have to be referred to our ab. *schmidtii*, Gerh." * It is certain, however, that specimens occur at all levels in which the

* *A Natural History of the British Lepidoptera*, vol. viii, p. 358.

ground-colour is a clear pale yellow. These cannot be mistaken for the cream-coloured ab. *schmidtii* or the brassy ab. *intermedia*, Tutt. The description "pallide lutea" of ab. *cuprinus* seems to fit this rare form quite well, so that the name may conveniently be accepted for it.

When examined with a lens, the ground-colour of the specimen under consideration is found to be composed of pale yellow scales among which are a few of a black or dark brown shade. These latter are scattered very regularly and sparingly, so that they produce not a suffusion but a dull tarnished effect, giving the insect an appearance altogether unique. One other named form, ab. *fulliolus*, Hulst, approaches it. This has only been found so far in North America, and is therefore at present restricted to the race *hypophlaeas*, Bdv. = *americanus*, D'Urb., which inhabits that continent together with a large part of the Arctic Region. It is described as follows :—

Hulst, "Ent. Amer.", vol. ii, p. 182 (1886). "*C. americanus* var. *fulliolus*, nov. var. A variety of this common species in which the coppery-red is replaced by an equally glowing somewhat sooty-yellow."

The description of this form, however, seems to suggest some slight degree of suffusion, while the ground-colour of the specimen in the Hope Department is not a "glowing yellow" but is rather dull and lustreless. It is probably better, therefore, to regard it as an example of ab. *cuprinus* modified by the sprinkling of dark scales referred to above.

Fig. 13 represents an insect even more interesting than that just described. It was captured on the wing at Milford, Surrey, 29 July, 1908, by the late Lt. R. J. Champion, B.A., Jesus Coll., Oxford. The spots on the fore-wings are below the average size, and a suffusion extends from the outer margin to within the distal series: towards the apex it encroaches to a greater extent, so as to reach the outermost of the two cell spots. This suffusion is extremely pale, being of a light greyish-brown colour, contrasting sharply with the spots themselves, which are black. The copper ground-colour is very bright and fiery and the Critical Spot * (the first in the distal series above the hind margin of the fore-wing) is turned with the concavity inwards. The hind-wings are normal, as is the whole of the underside. The true tail, which is that situated at the end of the second nervure, is practically absent, and the anal angle is not produced into a secondary tail-like projection.

The most noticeable feature of this insect is the extensive pale suffusion on the fore-wings; for it is extremely rare to find markedly suffused specimens of *phlaeas* as far north as the British Isles. In Europe, omitting the Arctic and sub-Arctic localities, there may be three or more broods in the year. These are divisible into two groups—the Constant and Racial Broods.† The former, which appear in the early spring and late autumn, are small, bright and typical in appearance, and very rarely show local variation. The latter appear in the summer and generally differ conspicuously from the Constant Broods in their marked tendency to form geographical races. There is, therefore, during development a critical temperature above which the resulting imagines are of the Racial Brood form and below which they assume the type of the Constant Brood. This critical temperature varies slightly according to the local race. The production of these two types of broods is the result of the seasonal alter-

* For a detailed account of the significance of this character, see *Trans. Ent. Soc. Lond.*, 923, pp. 704, 705, and 731, 732.

† See *Trans. Ent. Soc. Lond.*, 1923, pp. 695, 696 (Section 2).

nation of temperature acting over a comparatively long period of time, since the insects react but slightly to it in a single generation.*

Three zones of variation are thus established :—In Northern Europe the temperature is below that required to produce marked local races, and the insects are all of the Constant Brood type, though in the summer a brood corresponding to the more southern Racial Brood is developed and shows by its duller colour in warm years the effect which may be produced by a single season. In Southern Europe and North Africa both types of broods occur, while at the southern limit of the species, in Abyssinia and Uganda, the temperature seems always to be above the critical point and examples of the Constant Brood have never yet been seen there.

England is in the first of these three areas, and the specimen under consideration is one of those rare examples in which a number of circumstances must have combined to produce, in this country, a true example of the Racial Brood. It differs from the Constant Brood as completely as the specimens found in those more southern localities where both types are fully developed. The insect had doubtless been subjected to particularly warm and sheltered conditions during the pupal period, and its genetic constitution must have been of a favourable nature.

It is interesting to notice that the resulting specimen does not resemble any known racial form. In southern France and northern Italy the copper ground-colour is bright and fiery, while the suffusion is generally intensely black. On the Mediterranean coast of Asia Minor the suffusion is of a dull brown colour, but the remaining copper tint is yellowish and generally without the metallic lustre. In both forms the true tail is usually well developed. This insect resembles the former race in its bright copper ground-colour and the latter in its dull pale suffusion. Whether it approximately represents the race which would be produced in these islands if the temperature were high enough to permit of the formation of true Racial Broods, only prolonged experiment could show.—E. B. F.

Cyaniris argiolus, L., ♂. (Fig. 12.)

This interesting under-surface variety was taken by me in the New Forest, near Ashurst Lodge, about a mile-and-a-half from Lyndhurst Road Station, on 8 May, 1915. It is remarkable in the absence of all spots on the fore-wings except the central lunule, and the elongation of the spots on the hind-wings into streaks in place of the typical small round spots. (*E.M.M.*, 1920, p. 201.)

Ch. Oberthür in his *Variation chez Lépidoptères*, pl. iii, fig. 24, represents the undersurface of a specimen in which the hind-wing exactly corresponds with that here shown in Fig. 12, but the fore-wings also bear a series of radiate spots. He names this form *subtusradiata*, Oberth. The figure is reproduced in Tutt's *British Lepidoptera*, vol. ix, pl. xviii, fig. 10.

These examples are all the more interesting inasmuch as *C. argiolus* is, as a rule, a remarkably constant form.

Hipocrita (Euchelia) jacobaeae, L., ♂. (Fig. 10.)

This species like many others of similar coloration, *e.g.* the ZYGAENIDAE, sometimes, though very rarely, exchanges its crimson colour for a bright yellow. In this specimen, which was taken by Rev. G. Hughes, near Southampton about the year 1893, the change is, as it were, only beginning. The two spots on the

* See *Trans. Ent. Soc. Lond.*, 1923, pp. 694–695 (Section 1), and pp. 696–697 (Section 3).

hind margin of the fore-wing are yellowish and there are streaks of the same colour along the margins of the hind-wings. (*E.M.M.*, 1921, p. 12.)

Cucullia lactucae, W.V., ♂. (Fig. 2.)

The figure represents the first example of this species to be recorded as British. It was present in the collection of the late Mr. Arthur Sidgwick, M.A., presented to the Hope Department by his widow. The moth was bred by Mr. Sidgwick and labelled by him " Ox. 3.vi.00," and, on reference to his carefully kept and detailed diary, the name "*umbratica*," with his usual symbol for a bred specimen, appears under the date 3 June, 1900. There is nothing to indicate whether the moth was bred from a larva or from a cocoon—most probably the former as *Cucullia* cocoons are seldom found. Although the caterpillars of *lactucae* and *umbratica* are extremely different, it is quite possible that Mr. Sidgwick did not know the early stages of the latter, and when the moth emerged, took it for granted that his larva was that of *umbratica*. Very few people, unless they have reared it from the egg, have ever seen the larva of *umbratica*, which is very cryptic. In the moth stage *lactucae* is extremely like *umbratica*, the chief apparent difference being that it is rather bluer.

The two species being so very much alike it seems quite worth while for collectors in the South of England to look carefully through their series of *umbratica* lest by chance they should have placed a specimen of *lactucae* among them.

[This interesting specimen was recognised and recorded by Commander J. J. Walker, in *E.M.M.*, 1923, p. 8, and also described by Mr. Woodforde in *Entom.*, 1925, p. 178.]

Dysstroma concinnata, Steph. (Fig. 6.)

The figured example of this species was inadvertently replaced in the series without any reference to the plate and it is therefore unsafe to indicate its sex.

Seven undated specimens, of which Fig. 6 represents one, were taken by Mr. W. Smith in the I. of Arran and given by him to Prof. Raphael Meldola, F.R.S., who bequeathed his collection to the Hope Department of the Oxford University Museum (*Entom.*, 1921, p. 287). They are all so much alike that a photograph of any one specimen might be a photograph of any of the series. Other examples taken by Mr. Smith were sent to Mr. L. B. Prout, who has kindly written the following note :—

" This very interesting member of the difficult *truncata*-group seems clearly to have attained the status of a species on the island of Arran, as was shown by me on the evidence of the genitalia and bionomics (*Ent. Record*, xx, 143; *Trans. City Lond. Ent. Soc.*, xviii, 52–54), evidence furnished entirely by my good friends Mr. F. N. Pierce and Mr. W. Smith of Paisley; *cf.* Pierce, *Genit. Geom.*, p. 65, pl. xl."

Dysstroma truncata, Hufn., ♂. (Fig. 5.)

The specimen here figured is one of a series of five from the collection of the late Prof. Meldola. All were taken by him in August, 1914, at Tarbert, Loch Fyne, Argyll (*Entom.*, 1921, p. 287). The series is not so uniform as that of *concinnata* from Arran. Mr. Prout has kindly written :—

" The form recorded by Mr. Woodforde (*Entom.*, liv, 287) as a variety of *concinnata* with less of the rufous coloration, and here figured (a ♂ from Tarbert, August, 1914, ex coll. Meldola), remains somewhat of a puzzle.

I myself originally regarded some of these other Western forms as *concinnata* (*vide Trans. City Lond. Ent. Soc.*, xviii, 52), but Mr. Pierce pronounced the genitalia to agree with *truncata*. I am not aware that the matter has been followed up further, but I may add that Lochinver *truncata* are also sometimes extremely similar to those from the Hebrides."

Epirrhoë alternata, Müll., ♀ (= **sociata,** Bkh.). (Fig. 3.)

The aberration here figured was taken by me 7 June, 1920, on Cannock Chase (*Entom.*, 1920, p. 258; 1921, p. 288). Two somewhat similar examples are mentioned by Barrett (*British Lepidoptera*, vol. viii, p. 103). The fact that *alternata* is but little given to variation, except for a slight widening or narrowing of the central dark fascia, renders this example and the ab. *degenerata*, Haw. (Seitz, "Palaearctic Geometrae," p. 158), especially interesting. Mr. Prout contributes the following notes :—

"This striking aberration—a very extreme development of ab. *degenerata*, Haw.—has already been recorded and described by Woodforde (*Entom.*, liii, 286; liv, 288). A tendency for the median fascia of the fore-wing to 'degenerate' into more or less broken fragments is rather manifest in several species of the *Xanthorhoë–Epirrhoë* group (*X. fluctuata*, *X. montanata*, *E. rivata*, *E. tristata*), but the more advanced stages are always extremely rare. The fact that the 'discal spot' is independent of the fascia on which it stands is shown by its permanence in all cases where the fascia itself disappears. It is further interesting that aberrations in this category commonly show some compensating increase in the darkening in some other part of the wing. This is well shown in the broadly diffused subbasal band of the Cannock Chase specimen. The hind-wing likewise tends to participate in the abnormalities of the fore-wing, the markings being blurred and a rather pale space between the discal spot and the postmedian line showing a correlation with the evanescence of the median fascia of the fore-wing."

Xanthorhoë fluctuata, L., ab. **geomella,** n. ab., ♂. (Fig. 4.)

This species is extremely variable in the proportions of black, white and grey coloration, but the specimen here figured is probably unique. It was "taken at rest on a mossy wall" near Dunbar, on 12 July, 1912, by Mrs. Ella F. Meldola. The exact locality was the side of the road from the village of Spott, and the wall that of Lochend Park. This remarkable aberration has already been fully described by me (*Entom.*, 1921, pp. 287, 288), and I now propose for it the name suggested by the late Professor Meldola.

Mr. Prout, although in general "unconvinced of the necessity or utility of giving names to apparent 'sports' or unique aberrations," writes :—"In the present case, in deference to the wishes of a great man and out of respect to his memory, I can quite see the justice of making an exception. And after all, we can never venture to say that any form which has occurred is really—or will always *remain*—unique."

Bupalus piniaria, L. (Fig. 1.)

Such a perfectly halved gynandromorph as that here represented is extremely rare, but there is a very similar and equally well-divided example of *piniaria* from the collection of Mr. W. P. Blackburn-Maze, figured in Barrett's *British Lepidoptera* (vol. vii, plate 282, fig. 2*f*). The gynandromorph here represented is from the collection of the late Mr. Arthur Sidgwick. It was beaten in 1891

from a fir-tree on the road from Wellington College to Wokingham by Mr. H. C. Hayward, who gave it to Mr. Sidgwick, his tutor at Corpus Christi College, Oxford. [These data were kindly communicated by Mr. Hayward, who had seen Mr. Woodforde's reference to the specimen as "without data, from the Sidgwick Collection" in *Entom.*, 1925, p. 179.]

Mr. Prout writes :—

"The figure of this perfectly halved gynandromorph—right side ♂, left side ♀—renders further description unnecessary. I was under the impression I had seen a record of a similar example previously, but cannot lay my hands on it; Seitz, however, reports (*Zool. Jahrb., Abth. f. Syst.*, vii (5), 848) a gynandromorph of this species with both fore-wings ♂, both hind-wings ♀."

Chiasmia clathrata, L., ab. **nocturnata,** Fuchs. (= **nigricans,** Oberth.), ♂. (Fig. 11.)

I am indebted to Mr. Prout for the name of this variety (Seitz: *Macrolep. Palaearct.*, iv, *Geometridae*, p. 404, pl. 24 *c*), which is a very extreme aberration of a species in which the ground-colour is usually either white or pale yellow, crossed by four chocolate-coloured lines varying in breadth and sometimes occupying much of the space usually covered by the ground-colour. In this specimen, taken by the late Mr. W. G. Pogson-Smith, 21 August, 1902, at Nettlebed, Oxfordshire, the chocolate extends over the whole space of the wing except for a few white spots. (*Entom.*, 1922, p. 13.)

Mr. Prout has kindly contributed the following note :—"This extreme aberration, with its curious resemblance to some forms of *Hesperia malvae*, is well known, though always rare. Specimens of this aberration seem to bring out a point which would escape notice in a typical series, namely that the primary white spots in this species are, on each wing, the subterminals of cellules 6, 3 and 2. Other vestiges which remain seem liable to vary according to the individual specimen."

Zygaena trifolii, Esp., ♂. (Fig. 9.)

The figured specimen was taken in Sussex, 25 June, 1921, by Mr. T. H. L. Grosvenor, F.E.S., who presented it to the Hope Department. When any colour variation appears in the genus *Zygaena* the tendency is for the red to become pink or yellow, but occasionally, as in this specimen of *Z. trifolii*, melanism occurs. This, however, is very rare, and, so far as I am aware, only appears in *Z. purpuralis*, *Z. filipendulae* and *Z. trifolii*.

Eleanor Stoll-Bailey, pinx. *Vaus & Crampton, Ltd.*

VARIETIES OF BRITISH LEPIDOPTERA IN THE HOPE DEPARTMENT, OXFORD UNIVERSITY MUSEUM.

All the figures are of the natural size.

Explanation of Plate XXII.

All the figures are of the natural size.

Fig. 1. *Bupalus piniaria*, L., gynandromorph—taken in 1891 by H. C. Hayward, near Wellington College, Berks.
2. *Cucullia lactucae*, W.V., ♂—bred at Oxford by the late Arthur Sidgwick.
3. *Epirrhoë alternata*, Müll., ab., ♀—taken in 1920 by the late F. C. Woodforde, at Cannock Chase.
4. *Xanthorhoë fluctuata*, L., n. ab. *geomella*, ♂—taken in 1912 by Mrs. Ella F. Meldola, on a mossy wall near Dunbar.
5. *Dysstroma truncata*, Hufn., ♂—one of five specimens taken in 1914, by the late Prof. Raphael Meldola, at Tarbert, Loch Fyne.
6. *Dysstroma concinnata*, Steph.—one of seven similar specimens (undated), taken by W. Smith in the I. of Arran.
7. *Heodes phlaeas*, L., var., ♂—taken in 1918, by H. E. F. Onions, in the Burnt Woods, nr. Market Drayton, N. Staffordshire.
8. *Chrysophanus dispar*, Haw., ab., ♀—from the J. C. Dale Collection.
9. *Zygaena trifolii*, Esp., var., ♂—taken in 1921, in Sussex, by T. H. L. Grosvenor.
10. *Hipocrita* (*Euchelia*) *jacobaeae*, L., ab., ♂—taken, about 1893, by Rev. G. Hughes, near Southampton.
11. *Chiasmia clathrata*, L., ab. *nocturnata*, Fuchs, ♂—taken in 1902, by the late W. G. Pogson-Smith, at Nettlebed, Oxon.
12. *Cyaniris argiolus*, L., ab., ♂, under surface—taken in 1915, by the late F. C. Woodforde, near Lyndhurst Road Station, Hants.
13. *Heodes phlaeas*, L., var., ♂—taken in 1908, by the late Lt. R. J. Champion, at Milford, Surrey.
14. *Gonepteryx rhamni*, L., gynandromorph—taken about 1873, by F. W. Andrewes, at Caversham, near Reading.
15. *Brenthis euphrosyne*, L., ab., ♂—taken in 1895, by the late Prof. W. M. Geldart, near Oxford.
16. *Brenthis euphrosyne*, L., ab., ♂, under surface—taken in 1916, by Rev. C. F Thornewill, in Tubney Wood, near Oxford.
17. *Brenthis selene*, Schiff, ab., ♂—taken in 1913, by Rev. C. F. Thornewill, at Crowthorne, Berks.
18. *Aglais urticae*, L., ab. *ichnusoides*, Selys, ♀—taken, probably in 1886, by Hon. G. L. Parsons, at Birr Castle, Parsonstown, Ireland.
19. *Colias hyale*, L., ab., ♂—from the Spilsbury Collection.

POLLINATION OF AN AUSTRALIAN ORCHID BY THE MALE ICHNEUMONID *LISSOPIMPLA SEMIPUNCTATA*, KIRBY

By Mrs. Edith Coleman.

Communicated, with an Introductory Note, by Professor E. B. Poulton.
With an Appendix by Mr. A. M. Lea, F.E.S.

[Read June 6th, 1928.]

Plates XXIII, XXIV and One Text-figure.

[The interesting observations which form the subject of the following paper were first made by Mrs. Coleman's daughter, but afterwards frequently repeated by both naturalists at Upwey and Belgrave, Victoria. Mrs. Coleman has published an account of the discovery in *The Victorian Naturalist*, xliv, p. 20, May 1927; and p. 333, April 1928. The present paper was sent to the Entomological Society by Mr. A. M. Lea, F.E.S., together with the Appendix which records his own observations, and a number of letters from the authoress. I have extracted from these letters and others written to me a number of paragraphs which have been incorporated in Mrs. Coleman's paper or added as supplementary notes. I regret that there has been no opportunity to consult the authoress on the arrangement, but hope that it will meet with her approval. Her researches confirm and extend the work of Monsieur M. Pouyanne and Col. M. J. Godfery, of which a brief account with references was given in *Proc. Ent. Soc. Lond.*, ii, 1927, pp. 31–33. The method by which fertilisation is brought about is so new to us and so likely to suggest further discoveries that I have been glad to authorise a grant from the Oxford University Fund for promoting the study of Social and Organic Evolution, in order that it may appear, with the abundant illustrations provided by the authoress, in the *Transactions of the Entomological Society of London*.—E. B. P.]

Naturalists who have studied the interesting articles by Colonel M. J. Godfery in the *Journal of Botany*, concerning an unusual method of Orchid pollination, may like to read of a similar case here in Australia. In this instance a terrestrial Orchid is effectively pollinated by an Ichneumonid insect which enters the flower backwards and thus carries off the pollen on the tip of the abdomen instead of on its mouth-parts, or head.

The Orchid, *Cryptostylis leptochila*, F.v.M. (Pl. XXIII, figs. 1, 2, 3, and 4), only occurs in New South Wales and Victoria, but the Ichneumonid, *Lissopimpla semipunctata*, Kirby (Pl. XXIII, figs. 5, 6), is common to all the States. Furthermore, when the Orchid is transferred to a district where it is unknown the male Ichneumon almost at once detects its presence and seeks it.

The male only visits the Orchid and from its actions it is apparent that it regards the flower as a female of its own species, and enters it under this impression. The flower does to some extent resemble the female *Lissopimpla* both in shape and colour (see Plate XXIII), and it is fairly certain that it gives off a perfume which, though almost imperceptible to us, is attractive to the male.*

* Mrs. Coleman wrote, 14 March, 1928, in a letter accompanying some specimens she was sending to Mr. A. M. Lea :—" These are last year's flowers, but placed on a light paper and taken from above (as sighted by the insect) should give a very good idea of what resemblance there is.

Early in January, when the Orchid is at its best, the male Ichneumons are numerous and eagerly surround the flowering spikes. Frequently two insects will enter a flower simultaneously, one of them emerging with the pollinia adhering to its abdomen. The males are so absorbed that flowers, with their visitors, have been snipped off into a killing-bottle without disturbing them. On two occasions an Ichneumon became disengaged from the flower as it dropped into the bottle. It was removed, and after lying for a few seconds, apparently dead on the table, it revived and entered another flower.

When the male Ichneumon has alighted on a flower the two anterior pairs of legs embrace the labellum near to its centre. Then the posterior pair is drawn up and the abdomen curved so that the aedoeagus can enter a fleshy fold near the base of the abdomen (Pl. XXIV, fig. 3). Here it is that I expect to find spermatozoa when the insect has been left in the flower long enough to complete the act. If interrupted at each visit the Ichneumon will seek several flowers in succession, but not when it has been left undisturbed on the first flower. Thus cross-pollination is probably ensured, for by the time the insect experiences the desire again it will have flown to a flower upon another plant.

The Orchid's disc or gland adheres to the dorsal surface of what is apparently the last segment as represented in Pls. XXIII, fig. 5 and XXIV, fig. 2 (always exactly in this position), and when leaving the flower the pollinia are at right angles to the insect's body, afterwards falling to a position parallel with it and ready to touch the stigma of the flower next visited. The change in the direction of the pollinia is brought about by a slight depression of the caudicles and the contraction of the viscid disc as it hardens. The effect is aided by the straightening of the insect's abdomen, which, as it entered the flower, had assumed a falcate curve wonderfully adapted to facilitate the withdrawal of the pollinia clear of the stigma.

It is, I think, probable that, as in the observations described by M. Pouyanne and Col. Godfery, the eagerness of the males is due to their emergence before the females. Although I have seen scores of the former I have not yet come across a single living female. In the early part of the season the eagerness of the males is evinced by the exsertion of the aedoeagus, visible to the naked eye, when they hover above the flowers, and the opening of the claspers as may be seen in the dead specimens (Pl. XXIV, figs. 11, 12, 13) although not during flight. Later in the season when there are fewer visitors and these not so keen, many of them merely alight on the flower and do not enter. The claspers are then unopened and invisible.

The females of these Ichneumons are known to hunt for their insect victims close to the ground, but a number of males entered a room through an open window and visited some Orchid flowers that were resting on a shelf beneath it.

These observations, from a very different part of the world, entirely confirm the conclusions of M. Pouyanne and Col. Godfery, that flowers may offer

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I place more faith, however, in scent, or some other sense of which we know nothing. Here at Blackburn, where I never have more than three flowers open at a time now, I have seen the insect tack swiftly over, as if getting the scent, before alighting."

Dr. Rendle, F.R.S., in kindly sending the coloured drawing for reproduction on Plate XXIII, expressed his opinion that the resemblance of the flower to the female insect is unconvincing, as it certainly is taken by itself. Nevertheless, the paired dark spots on a lighter ground present a somewhat similar pattern to the white spots on a dark ground, and this, combined with the shape of the labellum probably serves to confirm and deepen by far the most important and probably the original stimulus of scent. It must be remembered, too, that, if the scent of this Orchid is faint to the human sense, that of the female moths which are sought by "assembling" males, is entirely imperceptible, and yet provides a stimulus effective over relatively immense distances.—E. B. P.

attraction other than nectar or food to their insect visitors, and that by so modifying their structure as to mimic the female of an insect they may obtain the service of the male as a pollinating agent.

I feel convinced that the adaptation has been brought about by slow modification on the part of the Orchid, for the especial purpose of achieving cross-pollination, possibly the result of chance in the first instance. The survivors among the Orchid offspring of that first chance " pairing " of insect and flower and the ensuing cross-fertilisation would reproduce in some degree the scent—for we must suppose that this was the primary stimulus—which had lured the insect to its parents. Then the shape of the labellum may have been modified by a similar selection of favourable variations, and, simultaneously, or at a later stage, the gleaming glands may have been rendered still more conspicuous and their pattern more like that on the Ichneumon's abdomen. Of course all this would, I conclude, take ages, for modification is immeasurably slow, and species within the limits of *our* observation appear to be fixed.

I am indebted to Mr. W. H. Nicholls for the coloured drawings reproduced on Plate XXIII, and to Mr. Tarlton Rayment, the Melbourne Hymenopterist, for the drawings represented on Plate XXIV.

Notes on the Presence of Spermatozoa.

[The following notes were extracted from letters written by the authoress to Mr. Lea and (that of June 12) to me.—E. B. P.]

2 *March*, 1928.—Concerning the spermatozoa, I have little doubt that I have seen them under the microscope, but will ascertain this more definitely later in the season. Several times when I have abstracted an insect soon after it has alighted on a flower there has been an apparent spherical globule of liquid on the tip of the abdomen. This, before the sex of the insect had been ascertained, I believed to be an egg or possibly more than one. This droplet should, as you suggest, afford positive proof of attempted copulation.

12 *March*, 1928.—I have made smears on a slide, as advised, which have been fixed either in absolute alcohol, or by passing quickly through the flame of a spirit lamp. I have then stained them with fuchsine, and as far as I can see there is no difference in the result under the microscope, between these and the bacteria in the nodules on the roots of lupin, clover, etc., which I have tested at the same time for comparison. I shall send you slides for your verdict, but will first test with a haemotoxylin or eosin stain to see if there is any appreciable difference. On the cover slips I have placed the actual drop from the tip of the abdomen, and on the slides I have made smears from the stigma and from the fleshy base of the labellum.

14 *March*, 1928.—The smear was made by placing the globule on a slide, and then adding a drop of saline solution. It was examined under the microscope in less than three minutes from the time of the insect's visit to the flower.

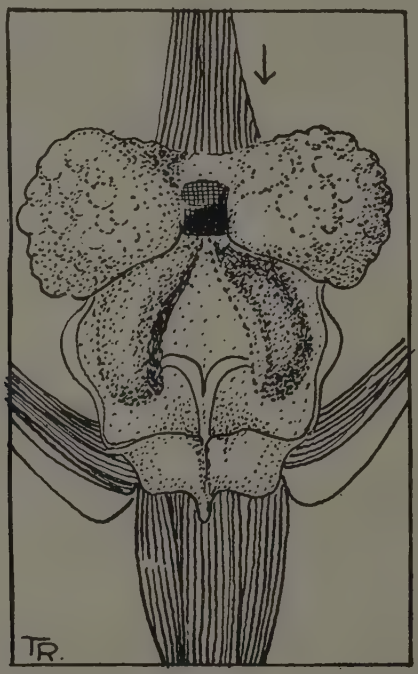
26 *March*, 1928.—Mr. Tarlton Rayment has dissected some of the males of *Lissopimpla* and sketched for me the spermatozoa: his drawings are exactly similar to the structures on my slides, which he had not seen.

12 *June*, 1928.—With regard to the spermatozoa, although I am confident that I have them on the slides they are very difficult to discriminate from vegetable matter, pollen grains, etc. I do not despair, however, for it was late in the season when it was suggested to me to take these smears.

Extracts from the Diary in which the Visits of the Ichneumon are recorded.

[The following extracts were copied from letters to Mr. Lea and to me.—E. B. P.]

I have my notebook before me, and you will gather something of the frequency of the visits if I copy the records of a few days. Sometimes half an hour would elapse before a male appeared, but in the mornings, in January and February, as soon as the flowers were exposed I could count on one or two visitors. I have held the spike in my fingers and watched the "pairing" with a magnifying glass. No one who saw it thus could doubt the object of the visit.



View of organs of flower with pollinia exposed; arrow indicates the direction of the insect's abdomen when being inserted. The labellum and petals have been removed: the dark spot is the disc. Anther turned down. From a drawing by Mr. Tarlton Rayment.

Several insects which I withdrew in the hope of getting a smear from abdomen returned to flowers at once when I released them.

On Jan. 28th and Feb. 17th they surrounded the flowers in large numbers—competition was keen, and two and three pairs of pollinia were carried frequently. This eagerness, and numerical strength of the male surely points to a dearth of females.

Feb. 23*rd*. One of the most inconspicuous of flowers visited. Flower was almost hidden—insect had to push its way between other flowers to reach desired one. Scent or sight?

Feb. 29th. . . . Three insects free to-day with pollinia attached to them.

March 2nd, 8.20 *a.m.* Two in almost instantly—away at once.

One in (pollen taken from this flower yesterday); competition keen.

Two in flower at once.

Flowers with pollen removed withering fast.

Another in and away—no pollen taken.

Another in and away—no pollen taken.

Two at once, one takes pollen.

Another in, pollen removed and flies off.

Another entered. I lifted spike and held it for long time, not even steadily: then put the Ichneumon, spike and all, into the killing-bottle, when he became free and recovered when liberated.

Two small ones enter; one takes pollen.

One large one enters and then three more which were disturbed and nothing taken. Another with pollinia alighted (looks like yesterday's pollinia—a bit battered about).

Another, took pollen (twisted round in releasing, pollen left on stigma but very little).

Another bearing pollen, enters.

Many are now flying round with pollinia from my Orchids, and the fact that only two have *returned* to flowers within an hour suggests satisfaction.

I think I can now safely say that unless competition is keener (as at Belgrave and Upwey) those that enter flower in obedience to the sexual instinct, remain, if undisturbed, for fully a minute and do not return to flower after freeing themselves.

At Upwey two and three pairs of pollinia on one insect were frequent.

Another round—did not alight.

Afternoon. Only one visited. No pollen taken.

Note. Insects, when satisfied, undoubtedly fly some distance before the impulse recurs, *and so reach fresh flowers.*

APPENDIX.

An Australian Insect mating with an Orchid.

By Arthur M. Lea, F.E.S., Government Entomologist of South Australia.

In the summer of 1926–7 Mrs. Edith Coleman, of Blackburn, Victoria, observed numerous Ichneumon wasps, *Lissopimpla semipunctata*, Kirby, entering the flowers of *Cryptostylis leptochila*, F.v.M., backwards, and performing certain actions which she at first presumed were in the nature of egg-laying; the Ichneumons, if not interfered with, always left with pollen attached to the tip of the abdomen. She wrote to Dr. R. S. Rogers of Adelaide, the Australian specialist on Orchids, about this, and showed him some of the Ichneumons, but they were males. Further investigation by Mrs. Coleman followed, and in January 1928 Dr. Rogers called on her and together they saw many male Ichneumons visit the flowers and repeat the operations exactly as Mrs. Coleman had seen them previously. The doctor obtained some of the flowers and took them to the room he was staying in, where, although the window was only partially open, the flowers were instantly visited by several of the Ichneumons.

From her lengthened experience with the Orchids and Ichneumons there

is now no doubt whatever but that the male insects are deceived by the flowers, and during their visits to them consider they are copulating with them.

The insect always enters backwards, opens the tip of its abdomen, apparently fastens the claspers to the fleshy fold at the base of the labellum, thrusts the aedoeagus into the stigma, and after certain movements are performed seminal fluid is ejected and part of it may be seen on the tip of the abdomen after its withdrawal; the tip of the abdomen presses on the gland of the pollinarium, which together with the pollinia is withdrawn from the flower, and fastened to the arched posterior section of the abdomen.

Many males were often seen struggling together to copulate with individual flowers. In one of her letters Mrs. Coleman says: "they surrounded the flowers in large numbers, competition was keen." At first she thought that some specimens in which the aedoeagus was exserted were females; but after seeing an undoubted female she now knows for certain that they were all males and that she has never seen a female visit the flower, nor has Dr. Rogers seen one visit it. She published in 1927 a preliminary note in *The Victorian Naturalist* and a more lengthy article in the present year (vol. xliv, pp. 20 and 333). In the next season, when the flowers are out, it is hoped to obtain some of the seminal fluid discharged by a male on a flower and to make photo-micrographs of the spermatozoa in it.

The benefit to the Orchid is certain, because through the visit of the insect fertilisation is ensured, and this could only be effected in some special way. Dr. Rogers has, himself, seen pollen deposited on the stigma by the Ichneumon on a subsequent visit.

In all probability the deception is primarily due to scent; and although the smell given off by the Orchid is faint, it is evidently sufficiently strong to attract the Ichneumons from some distance. It is now well known that the males of several kinds of Fruit-flies are attracted by certain strong-smelling liquids, kerosine and citronella, being evidently deceived by the resemblance of some constituent in the oil to the scent of their own females. But in this case the male is not only attracted to the flower, but actually performs the operations of copulation.

After the primary deception the shape and markings of the labellum probably serve to confirm and strengthen the deception.

The Ichneumon occurs in all the Australian States and New Zealand, and it is of considerable importance because of the variety of Lepidopterous insects which it helps to keep in subjection. The Orchid occurs only in Victoria and New South Wales.

This is the only known instance of the kind in Australia, but after Mrs. Coleman's article was published and whilst the investigation was proceeding the observers had their attention directed to papers by Col. Godfery * on the fertilisation of an Algerian Orchid of the genus *Ophrys* by a Scoliid wasp, *Dielis ciliata* (*Colpa aurea*) which is evidently also deceived and performs operations of a copulatory nature on the flower.

Dr. Rogers has seen these notes and agrees with them.

* *Journal of Botany*, 1925, p. 33, and 1927, p. 350. [See *Proc. Ent. Soc. Lond.*, II, 1927, pp. 31–33, for an abstract of Pouyanne's and Godfery's observations, and references. E. B. P.]

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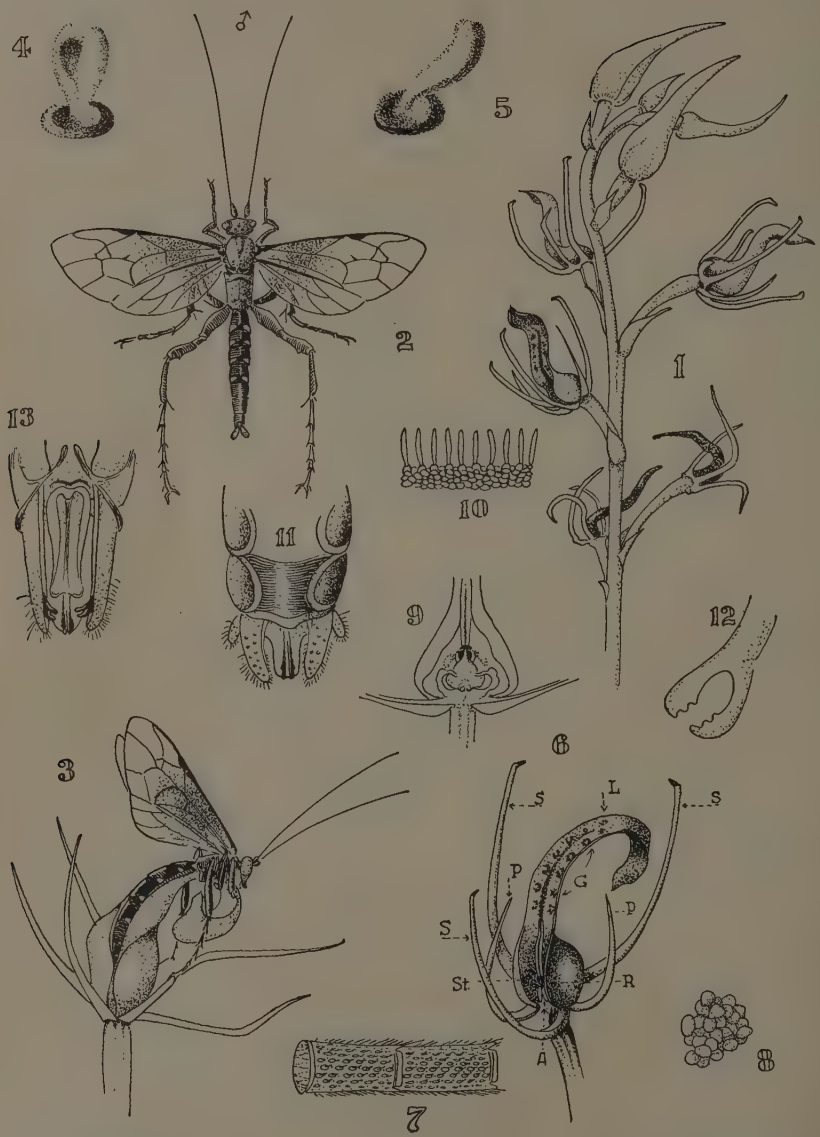
The Australian orchid *Cryptostylis leptochila*, F. d. M. (1, 2, 3, 4), cross-fertilised by the male of the Ichneumonid *Lissopimpla semipunctata*, Kirby (5), probably lured by a scent like that of its own female (6).



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The Australian orchid *Cryptostylis leptochila*, F. d. M. (1, 6, 9), cross-fertilised by the male Ichneumonid *Lissopimpla semipunctata*, Kirby, with which it attempts to pair (3), carrying off the pollinia (4, 5), on the end of its abdomen (2). Genitalia of male (11, 12, 13). Spores (8); section of labellum (10); antennal segments (7).

Explanation of Plates XXIII and XXIV.

Plate XXIII.

Pollination of the Australian Orchid *Cryptostylis leptochila*, F.v.M., by the male of an Ichneumonid.

Fig. 1. Flower fully expanded. Slightly enlarged.
2. A spike of *Cryptostylis leptochila*, F.v.M. Flowers natural size.
3. Leaves upper and under surfaces.
4. Pollinia greatly enlarged.
5. *Lissopimpla semipunctata*, Kirby, ♂, after visiting the orchid, showing pollinia on tip of abdomen. Slightly enlarged.
6. *Lissopimpla semipunctata*, ♀.

Plate XXIV.

Pollination of the Australian Orchid *Cryptostylis leptochila*, F.v.M., by the male of an Ichneumonid.

Fig. 1. Spike of flowers at various stages.
2. Ichneumonid, *Lissopimpla semipunctata*, Kirby, ♂, with pollinia attached to tip of abdomen.
3. Ichneumon with abdomen inserted, clasping the labellum. Feet, owing to contortion of insect in cyanide, are not in correct position.
4. The pollinia with viscid disc. (Each pollinium is bilobed.)
5. The disc hardens in a few seconds, and contracts, slightly depressing caudicles.
6. Enlarged view of flower: *L*, labellum; *S*, sepals; *P*, petals; *R*, rostellum; *St*, stigma; *A*, anther; *G*, glands: note fleshy fold at base of labellum.
7. Portion of antenna of Ichneumon, with pore-organs.
8. Pollen-granules detached from pollinium.
9. Enlarged view of base of labellum before the pollinia are exposed.
10. Section through labellum.
11. Ventral view of tip of Ichneumon's abdomen as it leaves the flower; palps and claspers are extruded.
12. Clasper highly magnified.
13. Genitalia of ♂ showing claspers that engage with the fleshy fold of the labellum.

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